[COMMITTEE PRINT]

SPACE ACTIVITIES OF THE UNITED STATES, SOVIET UNION, AND OTHER LAUNCHING COUNTRIES/ORGANIZATIONS, 1957–1983

REPORT

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SPACE SCIENCE AND APPLICATIONS

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LETTER OF TRANSMITTAL

HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE AND TECHNOLOGY,
Washington, D.C., April 5, 1984.

To All Members, Committee on Science and Technology:

There is transmitted herewith a Congressional Research Service updated report entitled, "Space Activities of the United States, Soviet Union and other Launching Countries/Organizations." The report is based on careful analysis of information contained in numerous unclassified sources and reviews the space activities of all launching countries and operations from a prognostic and statistical point of view.

I commend the report to your attention.

Sincerely,

DON FUQUA, *Chairman.*

LETTER OF TRANSMITTAL

HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE AND TECHNOLOGY,
Washington, D.C., April 4, 1984.

Hon. DON FUQUA,
Chairman, Committee on Science and Technology,
U.S. House of Representatives.

DEAR MR. CHAIRMAN: I am forwarding herewith an update of the Congressional Research Service report, "Space Activities Of The United States, Soviet Union, And Other Launching Countries/Organizations: 1957–1983." This report constitutes the most authoritative review of the Soviet space program in the open literature and serves as a significant reference document while providing a comparison to the United State's space program.

Sincerely,

HAROLD L. VOLKMER,
Chairman, Subcommittee on Space Science and Applications.

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LETTER OF SUBMITTAL

March 2, 1984

Honorable Harold Volkmer
Chairman, Subcommittee on
Space Science and Applications
Committee on Science and Technology
House of Representatives
Washington, D.C. 20515

Dear Mr. Chairman:

Pursuant to your request, we are providing a copy of the CRS report "Space Activities of the United States, Soviet Union and Other Launching Countries/Organization 1957-1983" for republication as a committee print. This report is an updated version of the edition published last year, and covers through December 31, 1983.

The report was updated by Marcia S. Smith, Specialist in Aerospace and Telecommunications Systems of the Science Policy Research Division. Mr. Geoffrey E. Perry, head of the Kettering Group in England, provided some of the data for the report.

We hope that these annual reports are helpful to your subcommittee in assessing the U.S. space program in comparison with the activities of the other launching countries and the European Space Agency. If we can be of further assistance, please let us know.

Sincerely,

Gilbert Gude
Director

Report No. 84-20 SPR

SPACE ACTIVITIES OF THE UNITED STATES, SOVIET UNION AND OTHER LAUNCHING COUNTRIES/ORGANIZATIONS: 1957-1983

Marcia S. Smith
Specialist
Aerospace and Telecommunications Systems
Science Policy Research Division

January 15, 1984

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The Congressional Research Service works exclusively for the Congress, conducting research, analyzing legislation, and providing information at the request of committees, Members, and their staffs.

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ABSTRACT

Five countries and one international organization currently have the capability to place satellites in space. The United States and the Soviet Union conduct the most comprehensive programs, and have been launching spacecraft for both military and civil purposes for over 25 years. The entry of countries such as Japan and the members of the European Space Agency into the space business has now introduced the element of economic competition in providing space services and hardware. This annual report reviews the space activities of the launching countries/organization--China, the European Space Agency, India, Japan, the Soviet Union, and the United States--both statistically and programmatically. This edition covers events through December 31, 1983, and highlights significant activities in 1983.

1983 SPACE ACTIVITIES AND 1984 PROSPECTUS

In 1983, there were 127 successful space launches in the world: 98 by the Soviet Union, 22 by the United States, 3 by Japan, 2 by the European Space Agency, and 1 each by China and India. There was one known launch failure: a Soviet manned mission was aborted on the launch pad after a fire erupted; the two cosmonauts on board were safely rescued. The Soviets also suffered the embarrassment of another unplanned reentry of a nuclear reactor-powered satellite, the second time this has happened.

A. MANNED SPACE ACTIVITIES

1. Soviet Union: A Mixed Year

For the Soviets, 1983 was a mixed year of successes and failures in the manned spaceflight area. On the positive side were successful flights related to development of two new vehicles (one a spaceplane, the other a multi-purpose space vehicle), and the successful installation of additional solar panels on Salyut 7 by the Soyuz T-9 crew. On the negative side were the inability of the Soyuz T-8 crew to dock with Salyut 7, a launch-pad abort of the Soyuz T-10 mission, and a fuel leak aboard Salyut 7.

o Spaceplane Tests. Two more tests of what the U.S. Department of Defense (DOD) has identified as a prototype spaceplane were conducted: Kosmos 1445

in March, and Kosmos 1517 in December. Added to the June 1982 flight of Kosmos 1374, these established a pattern of flight tests at nine month intervals.

Pictures of Kosmos 1445 released by the Australians showed a lifting body type of vehicle, with a cockpit window, what appear to be thermal protection tiles on the top and a carbon-carbon covering on the bottom. Unlike its two predecessors which landed in the Indian Ocean, Kosmos 1517 landed in the Black Sea after making what the Soviets called a "controlled descent," one more step in the development of the vehicle which may presage landings on a runway instead of water.

o Multi-Purpose Space Vehicle. The flight of Kosmos 1443 in 1983 was another step forward for the Soviets in manned orbital activities. Considerable attention was paid to Kosmos 1443 in the Soviet press, which characterized it as a combination space tug, cargo vehicle, and space station extension. Despite statements that it could increase the habitable volume of the space station by 50 percent, the Soviets instead filled the main body of the spacecraft with trash and allowed it to burn up in the atmosphere. Whether or not something went awry with Kosmos 1443 or Salyut 7 ending its mission prematurely is unclear.

o Another Docking Failure. Docking problems continued to plague the Soviets in 1983 when the Soyuz T-8 crew, the first manned mission of the year, could not dock with Salyut 7 because the rendezvous radar failed to deploy correctly. The crew was unable to judge its approach speed accurately enough to make a docking without it.

o Manned Launch Abort. On September 26, the Soviets added another space first to their record--the abort of a manned launch on the pad after a fire erupted in the launch vehicle. The two-man crew was carried away to safety by an emergency escape tower on their Soyuz T-10 spacecraft, and reportedly were not hurt.

o Manned Space Construction. The Soyuz T-9 crew, which remained on board Salyut 7 for longer than expected because of the launch abort, installed additional solar panels to the existing arrays on the space station to provide additional power for experiments. The exercise also demonstrated the ability of the crew to construct larger structures in space. The extravehicular activity (EVA) required for this event took place on two different days, the first time a Soviet crew has performed EVA twice on the same mission.

o Lost in Space? The most attention-grabbing event of 1983 was the allegation in the Western media that the Soyuz T-9 crew was in jeopardy following a leak in one of the Salyut 7 fuel lines and the launch abort of the Soyuz T-10 crew.

The original report was based on a misunderstanding by a British radio broadcaster of the lifetime of the Soyuz T-9 spacecraft which was needed to return the crew to Earth. The longest that one of these spacecraft had remained in orbit was 113 days, so he assumed that after that period, the crew would be unable to return. In fact, the design lifetime of the Soyuz T spacecraft was unknown at that time, but even it if were 113 days, the Soviets could have launched an unmanned Soyuz T to return the crew if needed (as they had done with Soyuz 34 in 1979).

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Despite repeated assurances by Western Soviet space experts and the Soviets themselves that the crew was not in danger, the Western media continued to report the event as a life-threatening emergency, right up until the crew returned safely to Earth on November 23.

o Uncharacteristic Candor. It was an unexpected treat for Western Soviet space observers when 1983 brought a series of articles in Krasnaya Zvezda and Pravda discussing the heroics of space crews when things go awry, and descriptions of two launch sites well known in the West, but previously unacknowledged by the Soviets. Lengthy articles by the commanders of the Soyuz 33 and Soyuz T-8 missions described their failures to dock with Salyut 6 and 7 respectively; while other articles described the northern launch site at Plesetsk where most military launches occur, and the small launch site at Kapustin Yar, from which the spaceplane tests have been conducted. Furthermore, the admission that a launch-pad abort had occurred on September 26 was unusual, and included the naming of the two men who were on board. At the same time, the Soviets conceded that Western reports of a fuel leak on the space station were correct.

2. United States: Back in the Game Again

For the United States, the manned program was one success after another in 1983. For the first time in ten years, the number of U.S. manned missions exceeded that of the Soviets: four (STS-6, STS-7, STS-8, and STS-9) compared to two. The four shuttle flights included the first American woman in space (Sally Ride), the first American black in space (Guion Bluford), and the

first flight of a non-American on an American manned mission (Ulf Merbold of West Germany). The shuttle program also inaugurated the use of the second space shuttle orbiter--Challenger.

Shuttle crew size grew during the year, with the first five-person crew on STS-7, and the first six-person crew on STS-9. The crews deployed a total of four satellites (one each for NASA, Indonesia, Canada, and India) from the cargo bay of the shuttle, deployed and then retrieved a payload using the Remote Manipulator System, and performed 10 days of experiments using the European-built Spacelab, which flies in the cargo bay of the shuttle. Two members of the STS-6 crew also performed the first U.S. EVA since the Skylab era.

Despite a few problems with the shuttle itself (the first flight in 1983, STS-6, had to be delayed by two months because of problems with the main engines, and the last flight of the year, STS-9, developed computer problems which caused the landing to be delayed for 8 hours), the year was filled with successes.

B. SPACE SCIENCE AND APPLICATIONS

1. Soviet Union

o Radars for Venus and the Arctic. Although the Soviets did not launch any of their military radar satellites in 1983, they did launch other satellites equipped with radars. Two were on probes that went into orbit around Venus in October and are sending back data with which to map the surface, while a third is on an earth orbiting satellite designed to track icebergs in the arctic.

o A New Earth Resources Spacecraft. The Soviets introduced a new sun-synchronous earth resources satellite, although it had a Kosmos rather than Meteor-Priorda designation. The relationship between the new satellite and the older program is unclear, and the Soviets continued to launch the two-week Kosmos missions in 82.3° orbits as well.

o Astronomical Satellites. Two observatory-class spacecraft were launched by the Soviets in 1983--ASTRON and Prognoz 9. Although large earth-orbiting scientific satellites have been launched in the past, none has been for all-sky astronomical surveys as these are. ASTRON carries instruments for detecting x-ray and ultraviolet radiation, while Prognoz 9 is for radio astronomy.

2. United States

The Tracking and Data Relay Satellite (TDRS) launched on the first shuttle mission of the year is the first of three satellites designed to replace most of NASA's existing terrestrial tracking network. The mission was almost lost, however, when the upper stage, used to take the satellite from the orbit of the shuttle to the higher geostationary orbit, failed and left the satellite in a non-usable orbit. Through the perseverence of ground control teams and a bit of good fortune in having more fuel on board than required, the satellite was finally nudged into a nearly-perfect orbit.

3. International Cooperative Projects

o IRAS: The InfraRed Astronomy Satellite. Launched by the United States, IRAS was jointly developed by the United States, the Netherlands,

and Britain. After returning data for 10 months, the satellite exhausted its supply of cyrogenic coolant, which was needed to keep the sensors at a temperature of -455°F.

Among the results was the discovery of what may be solar systems around two others stars, Vega and Fomalhaut. Although the data is still preliminary, it is the first empirical evidence scientists have had that our solar system may not be unique. Another surprise was evidence that a body as large as Jupiter may exist beyond the orbit of Pluto, but within the region of our solar system.

o Biosatellite. Launched four years later than expected, the Soviet Union finally placed the fourth of its biosatellites into orbit in December. Carrying experiments and equipment from the Soviet Union, United States, Bulgaria, Hungary, East Germany, Poland, Romania, Czechoslovakia, and France, the satellite remained in orbit for 5 days. Two monkeys, fish, and several pregnant rats were passengers aboard the satellite. Experiments were designed to study changes in metabolism, and the embryonic development of living organisms, during spaceflight conditions.

C. MILITARY SPACE ACTIVITIES

1. Soviet Union

There were more surprises in what the Soviets did not launch in their military program in 1983 than what they did launch. There were no launches of their co-orbital antisatellite (ASAT) device, or of the nuclear reactor-powered radar ocean reconnaissance satellites (RORSATs).

Reasons for the absence of an ASAT test are unclear, although some have speculated that the Soviets are trying to present an image of attempting to prevent an arms race in space. They offered a new draft treaty at the United Nations in August calling for a ban on the use of force in space, the dismantlement of existing ASAT system (although they did not admit that they have one), and a prohibition on the use of manned spacecraft for military purposes.

The lack of RORSATs may have been the result of the unexpected reentry of Kosmos 1402 in January. Launched in 1982, Kosmos 1402 should have split into two parts, with the instrument module decaying naturally, and the nuclear reactor portion going into a much higher orbit from which it would not decay until the radioactivity had subsided. Instead, the reactor portion did not move to the higher orbit, and the satellite broke into two parts which decayed separately in January (over the Indian Ocean) and February (over the South Atlantic). No additional radiation was measured at either site, and no pieces were recovered (as they had been after a similar incident in 1978). Whether the Soviets are redesigning the system, have abandoned this type of satellite, or are about to introduce a new model, is unclear.

2. United States

According to the trade press, the United States was supposed to conduct the first test flight of the F-15 ASAT device in 1983, but did not.

Nevertheless, the debate over space weapons heated up considerably following a March 23 nationally televised address by President Reagan

calling for development of measures to defend the country and its allies against ballistic missiles. Some of those concepts involve basing weapons in space, leading the press to dub this the "Star Wars" speech. Studies conducted for the Administration in 1983 concluded that a broad range of technologies, for both terrestrial and space based weapons, should be studied, and that no decision on development or deployment could be made at this time. The Reagan Administration continued to decline to negotiate with the Soviets over their draft treaty because conclusive methods for verifying compliance with such a treaty have not been identified.

D. CHINA, EUROPE, INDIA, AND JAPAN

Seven launches were made by the "other" launching countries/organization. China launched one satellite which was recovered, suggesting that it may be related to development of a military reconnaissance capability. India launched one earth resources satellite, a close cousin of reconnaissance, and began operation of the INSAT 1B communications/meteorology satellite launched for them by the United States.

The European Space Agency made two successful launches of the Ariane booster, placing three communications satellites in orbit. Japan conducted three launches of three payloads: one scientific, and two communications.

E. PROSPECTUS FOR 1984

Making predictions about the future is always difficult, particularly in the case of the Soviet Union and China where space activities are conducted

in secret. Nevertheless, it may be useful to speculate about what may develop in the year ahead, although these "predictions" should not be considered definitive.

1. Soviet Union

o "Superbooster" Test. Rumors about the imminent testing of the "superbooster" heightened in late December. The test of a vehicle with a thrust equivalent to the U.S. Saturn V has been expected since the late 1960s, and it would not be surprising if 1984 were the year in which it finally occurs. A new "medium lift" launch vehicle with an intermediate capability may also be tested.

o Spaceplane and Space Shuttle. Continued tests of the prototype spaceplane can be expected if the Soviets maintain the 9-month schedule used so far. A drop test of the larger shuttle-class vehicle from an airplane might also occur, although this is less likely.

o Space Station Module. Another Kosmos-1443 type vehicle may very well dock with Salyut 7, and might be a specialized module for materials processing (MPS) research. This would be consistent with the installation of the new solar panels on Salyut 7, since such experiments require large amounts of power. The module, which has considerable electrical power itself and a free-flight capability, might separate from the space station while the materials processing takes place to prevent interference from vibrations caused by crew activities. It could then redock so the crew could remove processed samples for return to Earth in the vehicle's descent module, and new samples could be added for processing.

o Permanent Occupancy of Salyut. This may finally be the year of a Soviet permanent manned presence in orbit, with replacement crews instead of rotating crews. At least one visiting crew can be expected, however, since the Soviets have announced that an Indian will fly into space in April 1984. It also would not be surprising if another woman cosmonaut were launched, perhaps making an EVA, as a U.S. woman astronaut is scheduled to do in 1984.

o VEGA Mission. The Soviets plan to launch the Soviet/French VEGA mission in December 1984, which will drop off balloons and landers at Venus and then continue on to an intercept with Halley's comet.

o Space Weapons Activity. Soviet ASAT tests may resume, especially if the United States tests its own ASAT device. A decision by the United States to negotiate with the Soviets over a treaty to ban ASATs may or may not have an effect on Soviet ASAT tests. When negotiations on such a treaty occurred in 1978, the Soviets conducted a test just before the talks began, but ceased testing during the negotiations.

2. United States

o Launch Schedule. NASA plans 22 launches in 1984 (not including 10 payload deployments from the space shuttle). Among them are 10 launches of the space shuttle, including 2 for DOD. Other DOD launches are not announced in advance.

o Shuttle Missions. The first 1984 shuttle flight will involve the first non-tethered EVA, during which an astronaut will test a backpack which contains both life support systems and maneuvering thrusters. If successful, the first operational use of this backpack will come on the next shuttle mission, where astronauts will attempt to retrieve, repair, and redeploy the Solar Maximum Mission satellite. Also scheduled is another flight of Spacelab, the second

TDRS launch, and the first use of the third space shuttle orbiter, Discovery. Six women are scheduled to fly on shuttle missions in 1984, and one is scheduled to become the first woman to make an EVA (if the Soviets do not do so first). For the first time, the shuttle should land at Kennedy Space Center, Florida, rather than at Edwards Air Force Base.

o Last of the Landsats. NASA will launch Landsat 5, the last of the approved Landsat satellites, to replace the ailing Landsat 4. Policy decisions on whether to continue Government support for the program or turn it over to the private sector if a buyer can be found will have to be finalized soon.

o Space Station Decision. A decision by President Reagan on whether or not NASA should construct a space station to enable the United States to have a permanent manned presence in orbit is expected early in 1984, with an announcment possible during the State of the Union address.

o Space Weapons. Reports in the trade press suggest that the first active test of the U.S. ASAT device will occur in 1984; Congress and the public should also learn the details of the President's decision regarding ballistic missile defense technologies, including space-based weapons, when the budget is submitted to Congress in January.

3. Other Countries/Organization

o China. If traditional patterns are followed, the Chinese will conduct one launch in 1984. They may also test a new cryogenic launch vehicle (the CZ-3) about which they have talked for several years, and said they would test in 1983, but this seems less likely.

o European Space Agency. ESA has four Ariane launches scheduled for 1984, which will place eight communications satellites in orbit, four for U.S. companies. During the year, launch responsibility will shift from ESA to Arianespace, a commercial organization established for this purpose.

o India. Another Indian launch can be expected in 1984 if traditional patterns are followed. As mentioned earlier, an Indian is scheduled to be launched as part of a Soviet space station crew in April.

o Japan. Japan has two launches scheduled for 1984, one a communications satellite and the other for weather.

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INTRODUCTION

Since October 4, 1957, when Sputnik 1 was placed in orbit by the Soviet Union, the question of Soviet-American rivalry in space and its broader implications have been matters of public concern, waxing and waning with the irregular occurrence of new space spectaculars. Sometimes the questions raised by space events have been matters of serious economic and military concern; other times they have been domestic and international political issues.

During the 1970s, developmental work on space launch vehicles was performed by several other countries. Three individual countries (China, India, and Japan) and one international organization representing eleven Member States (the European Space Agency) now have independent launch capabilities. The decade of the 1980s is likely to see the emergence of these entities as important factors in space utilization and competition.

The purpose of this report is to summarize the programs of the United States, Soviet Union, and these other "launcher" countries. Not included are efforts by private groups in the United States and abroad (such as OTRAG and Space Services, Inc.) that are attempting to develop their own orbital launch capabilities; if they succeed, these programs will be included in future editions of this report.

As shown in table 1, the countries of the world have made 2,513 successful launches of 3,446 payloads since 1957. In addition, there were 131 announced launch failures, and another 192 possible launch failures that were not announced by the Soviet Union and China. The United States and Soviet Union

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are responsible for 96 percent of the payloads successfully placed in orbit; these are categorized by mission in table 2.

Part I of this report is based on the report, "United States and Soviet Progress in Space," an annual report prepared from 1967-1980 by Dr. Charles S. Sheldon II, who died in September 1981. Part I has been revised and updated by Marcia S. Smith, Specialist in Aerospace and Telecommunications Systems in the Science Policy Research Division, who also wrote Part II. Mr. Geoffrey Perry, M.B.E., head of the Kettering Group in England, provided some of the data for the tables.

CRS has prepared several other reports on space which the reader may wish to consult for further information. A series of five-year studies on Soviet Space Programs has been prepared for the Senate Aeronautical and Space Sciences Committee (now part of the Senate Commerce, Science, and Transportation Committee) since the early 1960s. Volume I of the most recent edition covering 1976-1980 was published in 1983; Volumes II and III will be printed in 1984. World-Wide Space Activities, which provides detailed information on the space activities of all countries in the world except the United States and Soviet Union, was prepared for the House Science and Technology Committee in 1977. United States Civilian Space Programs 1958-1978 (Volume I) was published by the same House committee in 1981. Volume II, concerning applications satellites, was published in 1983.

Seven CRS issue briefs are also available on space topics: Star Wars: Antisatellites and Space-Based Ballistic Missile Defense, Issue Brief 81123; Space Policy and Funding: NASA and Civilian Space Programs, Issue Brief 82118; Space Policy and Funding: Military Uses of Space, Issue Brief 82117;

Space Shuttle, Issue Brief 81175; and Space Stations and Space Commercialization, Issue Brief 83147, all by Marcia S. Smith; and Landsat: Earth Resources Satellite System, Issue Brief 82066, and Commercialization of Landsat and the Weather Satellites, Issue Brief 83147, both by Patricia Humphlett.

This report is based on careful analysis of information contained in the numerous, unclassified sources cited in the above committee prints. Detailed citations are omitted for the purpose of keeping this annual update brief. The most frequently used sources, however, are publications of the Foreign Broadcast Information Service (FBIS), the Joint Publication Research Service, and trade publications such as Aviation Week and Space Technology and Aerospace Daily.

TABLE 1a: WORLD-WIDE RECORD OF KNOWN SUCCESSFUL SPACE LAUNCHES

YEAR	USSR	US*	FRANCE	AUSTRALIA	CHINA	JAPAN	UK	ESA**	INDIA	(ITALY)*	TOTAL*
1957	2										2
1958	1	5									6
1959	3	10									13
1960	3	16									19
1961	6	29									35
1962	20	52									72
1963	17	38									55
1964	30	57									87
1965	48	63	1								112
1966	44	73	1								118
1967	66	58*	2	1						(1)	127
1968	74	45									119
1969	70	40									110
1970	81	29	2		1	1				(1)	114
1971	83	32*	1		1	2	1			(2)	120
1972	74	31				1				(1)	106
1973	86	23									109
1974	81	24*				1				(2)	106
1975	89	28	3		3	2				(1)	125
1976	99	26			2	1					128
1977	98	24				2					124
1978	88	32			1	3					124
1979	87	16				2		1			106
1980	89	13				2			1		105
1981	98	18			1	3		2	1		123
1982	101	18			1	1					121
1983	98	22			1	3		2	1		127
TOTAL	1,636	822*	10	1	11	24	1	5	3	(8)	2,513

* Italy has made a total of eight launches from its San Marco platform off the coast of Kenya in the years indicated. Because all of these launches were made using U.S. Scout rockets, they are counted by NASA, and here, as part of the U.S. launch total. In previous issues of this report, four (1 in 1967, 1 in 1971, and 2 in 1974) were counted separately; thus, the U.S. totals for these years now have been increased by that number.

**European Space Agency

TABLE 1b: WORLD-WIDE RECORD OF KNOWN SPACE LAUNCH FAILURES

YEAR	USSR*	US	FRANCE	AUSTRALIA	CHINA*	JAPAN	UK	ELDO**	ESA**	INDIA	TOTAL*
1957	?	1									1
1958	?	12									12
1959	?	10									10
1960	2+?	13									15
1961	?	12									12
1962	?	7									7
1963	?	8									8
1964	?	7									7
1965	?	7									7
1966	?	4				2					6
1967	?	3				1					4
1968	?	3						1			4
1969	?	1			1	1		1			4
1970	?	1			?	1	1	1			4
1971	?	3	1		?			1			5
1972	?	2			?						2
1973	?	2	1		?						3
1974	?	1			?						1
1975	2+?	3			?						5
1976	?	0			?	1					1
1977	?	2			?						2
1978	?	1			?						1
1979	?	0			1+?				1	1	2
1980	?	2			?						3
1981	2+?	1			?						3
1982	?	0			?				1		1
1983	1+?	0			?						1
TOTAL	7 (188?)*	106	2		2 (4?)*	6	1	4	2	1	131 (323?)*

* The Soviet Union and China traditionally do not report launch failures. In the rare instances where failures have been admitted by those countries or reported in the Western literature, they are shown here; in all other cases question marks are used. The "total" column for these two countries show those launch failures which have been publicly identified, plus a total in parentheses with a question mark. The latter number has been estimated by applying the U.S. failure rate to their launch success rate on the assumption that their development programs encountered similar difficulties. The total for all countries for all years of (314?) includes these estimates, while the total of 131 does not.

** ESA is the European Space Agency. ELDO was the European Launch Development Organization which was merged into the newly established ESA in 1975.

TABLE 1c: WORLD-WIDE RECORD OF PAYLOADS SUCCESSFULLY LAUNCHED*

YEAR	USSR**	US#	FRANCE	AUSTRALIA	CHINA	JAPAN	UK	ESA	INDIA	(ITALY)†	TOTAL
1957	2										2
1958	1	5									6
1959	3	10									13
1960	3	17									20
1961	8	35									43
1962	26	59									85
1963	20	62									82
1964	39	73									112
1965	76	97	1								174
1966	52	101	1								154
1967	75	88	2	1						(1)	166
1968	85	64									149
1969	80	66	3								149
1970	103	40†	1		1	1				(1)	146
1971	114	54†			1	2	1			(2)	172
1972	109	42†				1				(1)	152
1973	130	26									156
1974	114	28				1				(2)	143
1975	140	35†	4		3	2				(1)	184
1976	141	34			2	1					178
1977	125	29				2					156
1978	142	41			1	3					187
1979	126	18				2	1				147
1980	132	16				2			1		151
1981	125+23**	20#			3	3		5	1		180
1982	119+22**	20#			1	1					163
1983	116+22**	30#			1	3		3	1		176
TOTAL	2,206+67	1,110	12	1	13	24	1	9	3	(8)	3,446

* In previous editions, payloads to earth orbit, and to the Moon and beyond, were reported separately for the United States and Soviet Union. This table shows all payloads, regardless of destination.

** The Soviet Union uses launch platforms for placing satellites into highly elliptical, geostationary, and deep space orbits. This report has traditionally included the platform as a separate payload. Beginning in 1981, the Soviet totals are shown as two numbers: total number of payloads + total number of platforms. The yearly totals are shown in the same manner. This is to provide some consistency in the manner in which payloads are counted for each country, since upper stages (such as the inertial upper stage carried in the space shuttle cargo bay) are not counted separately for the United States.

(footnotes continued on next page)

FOOTNOTES FOR TABLE 1c (continued)

The space shuttle is counted as 1 payload, regardless of what it carries. Satellites deployed from the cargo bay are counted as additional payloads if they are left in orbit, even if they are retrieved on a later shuttle mission. Payloads deployed and retrieved on the same shuttle mission. such as SPAS-01 in 1983, are not counted as separate payloads. Upper stages such as IUS or PAM are not counted as separate payloads.

† Italy has launched a total of 8 payloads from its San Marco platform off the coast of Kenya in the years indicated. Because all of these launches were made using U.S. Scout rockets, they are counted by NASA, and here, as part of the U.S. total. In previous issues of this report, four (1 in 1967, 1 in 1971, and 2 in 1974) were counted separately; thus, the U.S. total for these years now have been increased by that number.

TABLE 2. Summary of U.S. and Soviet Payloads by Mission 1957-1983 *

Category	United States 1983	United States Cumulative 1957-1982	Soviet Union 1983	Soviet Union Cumulative 1957-1982
Orbital launch platforms	--	--	22	248
Earth orbital science **	3	179	4	182
General engineering tests	0	28	0	2
Launch vehicle tests	0	11	0	16
Applications				
Communications	11	171	13	129
Weather	3	81	1	55
Geodesy	0	19	1	22
Earth resources	0	6	11	18
Man and biology related				
Earth orbit man-related	0	13	5	67
Earth orbit manned	4	25	2	57
Lunar man-related	0	17	0	8
Lunar manned	0	20	0	0
Deep space (other than man-related)				
Moon	0	25	0	34
Mercury	0	1	0	0
Venus	0	8	2	29
Mars	0	9	0	16
Outer planets	0	4	0	0
Interplanetary space	0	8	0	0
Military observation				
Low orbit recoverable (photo?)	2	236	27	558
Low orbit non-recoverable (elint?)	0	81	6	74
Minor military (calibration?)	0	43	7	129
High orbit (early warning?)	0	42	3	30
Ocean surveillance	6	12	2	39
Navigation	1	41	13	73
Tactical and store/dump communications	0	0	19	293
Weapons-related				
Fractional orbit bombardment	0	0	0	18
Targets for anti-satellites	0	0	0	18
Anti-satellite interceptors	0	0	0	20
GRAND TOTAL	30	1,080	138	2,135

* Mission assignments are arbitrary to a degree, and are subject to revision each year as more information becomes available. Qualifying footnotes would fill many pages. Perhaps arbitrary assignments by category which may be either too high or too low sufficiently cancel out simplifications so that the totals for military and civil are generally indicative of divisions.

** Includes amateur radio satellites such as OSCAR, Radio, and Iskra 2 and 3. For 1982, includes two Soviet satellites which may have an elint mission rather than ocean science.

PART ONE

U.S. AND U.S.S.R. SPACE ACTIVITIES

CHAPTER ONE: BRIEF HISTORY

A. WORLD WAR II

Building upon a foundation of scientific principles common to much of the world, the Germans developed to a high degree of engineering success the technology of long-range guided rockets, of which the V-2 was the most spectacular. At the end of the war, most of the leading German rocket scientists and engineers surrendered to the United States, while smaller numbers and the Peenemunde missile development center came under Soviet control. The German experience stimulated interest in rocketry, and their practical knowledge was quite useful, but it would be a mistake to judge the primary rocket programs of either the United States or the Soviet Union as depending exclusively upon this captured talent. The Russians in particular had a strong tactical rocket program in World War II, and as they moved into long-range ballistic missiles and space, they reportedly did not use Germans directly in their work on any significant scale.

B. THE INTERNATIONAL GEOPHYSICAL YEAR (IGY)

In 1955 both the United States and the Soviet Union announced their intentions to launch small scientific satellites by 1957 as a contribution to world understanding of Earth and space physics. The U.S. project was to be called Vanguard, with a payload of about 9 kilograms. Fewer details were available about Soviet plans.

C. SPUTNIK VS. VANGUARD AND EXPLORER

The general public, and many specialists who might have known better, were caught off guard when Sputnik 1 was placed in Earth orbit, with a weight of 84 kilograms. Few had supposed that the "backward" U.S.S.R. would beat the scientifically-advanced United States in this particular endeavor. One Western reaction was that this and subsequent Soviet achievements were fakes; and another reaction was one of near panic with thoughts of bombs dropped from orbit. Sputnik 2, launched November 3, 1957, did not help U.S. complacency when it was disclosed to weigh 508 kilograms, and to carry a live dog, Layka. U.S. discomfiture, at the very least, was heightened by the explosion on the pad of the widely-advertised first launch attempt of a 2-kilogram Vanguard on December 6, 1957. On May 15, 1958, Sputnik 3 went into orbit as a comprehensive orbital laboratory of 1,327 kilograms. Meanwhile the United States had outpaced its own Vanguard series (Navy-built for the National Academy of Sciences) with Explorer 1 (Army-built) of 8 kilograms payload on January 31, 1958 (Eastern Standard time). Vanguard 1 was launched March 17, 1958.

CHAPTER TWO: MANNED SPACEFLIGHT

A. EARLY MANNED SPACEFLIGHT

1. Vostok vs. Mercury

While Mercury was still in its testing stage in the United States, with the goal of placing a man in Earth orbit for a nominal three orbits in a 1,360 kilogram ship, the Soviet Union moved more rapidly in this field, too, by exploiting its then larger launch vehicles. Starting in May 1960, test flights of a 4,700 kilogram ship were conducted, with the first successful recovery of two dogs in August of that year. On April 12, 1961, Yuriy Gagarin was placed in orbit in Vostok 1 for a single circuit of the Earth, and in the following August, German Titov repeated the flight but for 17 orbits.

Alan Shepard on May 5, 1961 in a Mercury Redstone (Freedom 7) had flown for 15 minutes about 480 kilometers downrange from the Cape. "Gus" Grissom repeated this type of flight on July 21, 1961. But John Glenn was the first American to make it all the way to orbit with his three loops on February 20, 1962 in a Mercury Atlas (Friendship 7).

The Soviet Union flew the next two sets of Vostok flights in pairs in 1962 and 1963, with a near co-orbit in one case and a near pass in the other. Valentina Tereshkova, the first woman to go into space, in her 48 orbits (with Vostok 6) gained more orbital time than all six Mercury astronauts combined (34 orbits).

2. Gemini vs. Voskhod

The Russians were able to achieve some more firsts with Voskhod 1 in October 1964 which carried the first three man crew, and Voskhod 2 in March 1965 which provided the first 10-minute "space walk" (EVA) by Leonov. But after that the balance swung fairly sharply to the United States which conducted ten successful Gemini flights without any Soviet manned flights in the same period (1965-1966). U.S. two-man Gemini ships of about 3,600 kilograms weight were able to maneuver to change orbit, to rendezvous, and to dock with Agena target vehicles on several occasions. Using the Agena as a pusher rocket, Gemini flew as high as 1,369 kilometers, a new record. The United States also gained about 12 hours of EVA experience.

3. Apollo 204 and Soyuz 1 and 11 Tragedies

Before NASA could make the first manned launch with Apollo, there was the disastrous Apollo fire of January 27, 1967 which took the lives of three astronauts. This was both a great shock to the Nation and set back the program almost two years.

The Soviet Union had its own tragedy three months later, on April 24, 1967, when it tried to recover its first manned flight of the new Soyuz series. The parachute lines in the final phase of recovery became twisted, and Vladimir Komarov became the first human being to be killed in return from a space flight. This set back the Soviet program almost two years also.

A second tragedy in the Soyuz program occurred at the end of the Soyuz 11 mission on June 29, 1971. The three man crew had spent three weeks on Salyut 1 and were returning to Earth in their Soyuz capsule when they fired explosive bolts to separate their orbital work compartment and service

module from the recoverable command module. A valve linking the two habitable compartments remained open and the cabin atmosphere vented into space. The men were not wearing spacesuits and quickly were asphyxiated.

4. The Apollo Program

After test flights in Earth orbit, NASA took the bold step on December 21, 1968 of launching Apollo 8 with Frank Borman, James Lovell, and William Anders on the first manned Saturn V for ten close orbits of the Moon. The Apollo 11 flight, launched July 16, 1969, permitted Neil Armstrong and "Buzz" Aldrin to become the first men to set foot on the lunar surface on July 20, while Mike Collins orbited overhead.

Apollo 13, launched April 11, 1970, provided the most harrowing Moon mission when an explosion in the service module disabled some systems and cut consumable supplies, so that the crew, committed to going on, circumnavigated the Moon, using the lunar landing module as a lifeboat for all but Earth reentry.

The final flight, Apollo 17, launched on December 7, 1972, was the sixth successful manned landing, and the third to use a roving manned vehicle on the surface. In all, the six crews which landed on the Moon brought back approximately 380 kilograms of lunar soil and rocks.

5. Free-Flying Soyuz Flights

Soyuz manned flights resumed in October 1968, and by January 1969 had been used to dock two ships together (Soyuz 4 and 5), permitting crew transfer through EVA. Soyuz 6, 7, and 8 by October 1969, made a group coorbital flight with seven men but no dockings. Soyuz 9 set what was then a duration record by staying in orbit 18 days with a two-man crew. Soyuz 12 was a manned diagnostic

flight after the Soyuz 11 tragedy. Soyuz 13 of December 1973 was a manned astronomical observatory flight. Soyuz 16 of December 1974 was a trial run for the Apollo-Soyuz flight to follow. Soyuz 22 in September 1976 was a manned Earth resources flight using a multispectral camera system from the German Democratic Republic.

6. The Moon Race

When President Kennedy asked Congress to support Project Apollo in 1961, his advisors had told him that sending men to the Moon was a project in which the United States had a good chance of being first. They were right, but it would have taken very little different to have come in second.

Many analysts had expected the Russians to be first to make a manned circumlunar flight, possibly to coincide with the fiftieth anniversary of the Soviet state in November 1967. The program slipped, but Soviet unmanned precursors in the Zond series accomplished this mission several times with improving success. Five Zond spacecraft (based on the Soyuz design) made lunar-related flights from 1968-70. Apollo 8 was the first spacecraft to carry men to the Moon, however, and it remained in lunar orbit for several days, somewhat beyond the capability of the Soviet Zond flights.

In the early 1960s, Khrushchev made seemingly contradictory statements as to whether the Soviet Union was working actively on a lunar landing program, but in net balance his statements and those of other Soviet officials seemed to indicate they were. Until a few months before the Apollo 8 flight, Soviet cosmonauts were saying that when the Americans landed, they would find the Russians there to greet them. This talk ceased until new predictions were made in 1969. In April and June, respectively, Shatalov and Leonov, both

senior cosmonauts, predicted that a Soviet manned landing and return would be accomplished some time between October 1969 and the early part of 1970, preceded by some unmanned tests of the entire system. This would seem to indicate that Soviet space officials thought whatever engineering difficulties had held up the unveiling of their very large (G) vehicle had finally been solved.

In actual fact, the absence of appropriate Soviet flights during the summer and fall of 1969 probably indicated that whatever hopes were present in the spring had not been fulfilled. In an October 1969 statement by Keldysh, then President of the Soviet Academy of Science, he suggested that immediate plans for manned lunar flights had been set aside, but not precluded for the future. This admission in itself seemed to give substance to there having been such plans earlier. Further, the statement had the advantage of taking the public pressure off their program in the face of delays. But it must be added, it is not clear from what is known of the Soviet program that they had the means to conduct at so early a time a manned lunar landing. Not only would the expected big G vehicle have to be operational, but it would require either high energy upper stages, or have to be used in some pattern of rendezvous operations. The lack of evidence of readiness to go either of these paths as early as 1969 surrounds the cosmonaut predictions with questions. There is circumstantial evidence that subcomponents for manned lunar flights beyond the Zond circumlunar program were flight tested by Kosmos 159 (1967), Kosmos 379 and 382 (1970) and Kosmos 398 (1971). A fourth satellite with similar characteristics to Kosmos 379 and 398 was launched in 1971 and reentered in 1981. The Soviets announced at that time that the spacecraft, Kosmos 434, was a test flight of a lunar cabin. Some of these might have been used for future lunar

orbit rendezvous options as their changes of velocity matched requirements for entering lunar orbit and for descending to the surface of the Moon, and returning to Earth.

7. Apollo-Soyuz Test Project

As a contribution toward detente, and as a spur to the development of a universal, androgynous docking system, the United States and Soviet Union agreed to work cooperatively to develop and to conduct a joint flight in which an Apollo carrying a special docking module would rendezvous and dock with a modified Soyuz. The flights began on July 15, 1975. Soyuz 19 was sent up from Tyuratam with Leonov and Kubasov, while the Apollo was launched from the Kennedy Space Center with Stafford, Slayton, and Brand. The two crews paid exchange visits after docking and performed joint experiments. Soyuz 19 returned to Earth after 6 days, and Apollo after 10 days.

ASTP came off technically without a serious hitch, but was quite controversial. Challenges were made on the grounds of cost, safety, technology transfer, and Soviet image-building. Because the program was largely dead-ended technically, and the amount of science was slight in relation to the investment, the cost was criticized. Unknown problems of systems compatibility and worries about Soviet equipment unreliability led to some political demands that the program be suspended for much more detailed studies. There were worries that the United States was giving away more technology than it was gaining. A Soviet program which had faltered was presented to the world as an equal partner through ASTP. The Soviet investment in test flights and back-up hardware was probably at least as great as the U.S. investment in the

docking module which it supplied. Most of the safety charges lodged against the Russians were based upon launcher problems such as their April 5, 1975 aborted Soyuz, not wholly applicable to the space orbital meeting. Both sides were rather careful not to give away really private technology. The Russians surely gained first hand insights into NASA management methods and documentation, and the Americans visited Soviet facilities and people never before available. It is not clear that the Soviet program needed a political boost in image considering its massive size and many successes.

B. FIRST-GENERATION SPACE STATIONS

1. Salyut 1-5

The Salyut 1 space station, weighing 18.6 tons, was placed in orbit on April 19, 1971. When docked with a Soyuz, it had about 100 cubic meters of interior space, compared to 275 cubic meters in the American Skylab space station (without the Apollo spacecraft).

Soyuz 10 was launched with a crew of three, docked with Salyut, but for unstated reasons they were not able to enter the station, so returned to Earth in 2 days. Soyuz 11 was also docked, and its mission ran 24 days long, successfully conducting medical, Earth resources, and astronomical experiments. This was the crew that died during preparations to reenter the atmosphere.

Salyut 2 failed early in its mission, after launch on April 3, 1973. This was followed by Kosmos 557, launched May 11, 1973, intended to be a Salyut, which failed as it reached orbit.

Salyut 3 was launched July 3, 1974, and differed from Salyut 1 in being a military vehicle by strong implication. (Indicators: An all military crew, telemetry and frequencies akin to other military flights, and a low orbit to improve Earth picture resolutions.) It was visited by Soyuz 14 during a 16-day flight. Soyuz 15 also went up to the station but was not able to dock and returned to Earth after only 2 days. The station continued to function in automatic mode and returned a data capsule in September 1974.

Salyut 4, launched December 26, 1974, was another civilian mission, flying higher than the military type, using the usual manned-flight frequencies and open communications. Soyuz 17 made a 30-day flight, with the crew in the station. On April 5, 1975, a Soyuz was launched to carry a crew to Salyut 4, but a problem in the booster rocket required an automatic abort which brought the crew back to Earth (unharmed) about 20 minutes after launch. Soyuz 18 followed, and conducted a 63-day mission, then the Soviet duration record. Soyuz 20 in November 1975 was the first automated, unmanned "resupply" flight to a station (Salyut 4), a 91-day mission.

Salyut 5, another military station, was launched June 22, 1976. Soyuz 21 was launched on July 6, and conducted a 49-day mission with the crew occupying the station. On October 14, Soyuz 23 attempted a revisit to Salyut 5, but was not able to complete the rendezvous, and returned to Earth after 2 days. Subsequently, on February 7, 1977, Soyuz 24 was launched on an 18-day mission and the crew reoccupied the station. A capsule was returned the day after the crew left.

2. Skylab

After the Apollo Moon flights ended, the United States used a spare Saturn V to place in orbit a modified S-IVB stage equipped as a space station. Called Skylab, it was launched on May 14, 1973. Three Saturn I B vehicles were used to send up modified Apollo ferry craft to dock with Skylab. These missions lasted 28, 59, and 84 days respectively. A wide range of experiments were conducted successfully, especially impressive since the crews had to make difficult repairs to the station which had been damaged during launch.

C. SECOND GENERATION SPACE STATIONS

1. Salyut 6

On September 29, 1977, the Soviets launched a second-generation space station called Salyut 6. The most important improvement in the station was the addition of a second docking port at the aft end of the station which enabled resupply flights to dock with the station while a crew was on board. Flights of a new unmanned cargo ship, called Progress, began in 1978, and the first in-space fuel transfer took place between Progress 1 and Salyut 6 in January of that year. Progress is a modified Soyuz spacecraft which is not designed to survive reentry. The second docking port was also used to enable additional crews to occupy the station as visitors to the long-duration crew. This provided additional opportunities for taking supplies to the orbiting crew, and for bringing the results of the various experiments conducted on board back to Earth (which would otherwise have to wait until the main crew returned).

During its four and a half years in orbit, Salyut 6 hosted 16 crews (2 other manned missions were unable to dock) which conducted a wide variety of Earth resources, materials processing, biomedical, and biological experiments (such as plant growth). The station was occupied for approximately 50 percent of the time it was in orbit. A total of 12 Progress flights resupplied the crews, and three other unmanned missions (Soyuz 34, Soyuz T, and Kosmos 1267) docked with the station. These missions are highlighted below.

On October 9, 1977, Soyuz 25 carried a crew up to enter the station, but a hard docking was not achieved and the crew brought their Soyuz to Earth 2 days after launch. Another attempt was made on December 10, 1977, with Soyuz 26, and this time the crew was able to enter the station, using the second docking port. This started a program which brought a full flowering of the Soviet Salyut space station program. The Soyuz 26 crew set a world duration record of 96 days, sharing the station for a time with the crew of Soyuz 27 with whom they traded ferry craft, and received fresh supplies of consumables and instruments in Progress 1. They also had a visit from the crew of Soyuz 28, which included the first Czech cosmonaut.

Soyuz 29 was launched on June 15, 1978, with a fresh crew for Salyut 6, and set even greater records. They stayed up 140 days, trading ferry craft with the crew of Soyuz 31. They had visits from Soyuz 30 with a Polish cosmonaut and Soyuz 31 with a German Democratic Republic cosmonaut. Resupply missions were made by Progress 2, 3 and 4.

Soyuz 32, launched on February 25, 1979, brought the third long-duration crew to Salyut 6. They were to be visited by the crew of Soyuz 33 including a Bulgarian cosmonaut, but the ship could not dock because of an engine failure. Soyuz 34 was sent up unmanned to replace the aging Soyuz 32, later returning

the crew to Earth after a record stay of 175 days. Also during 1979, the station was replenished by Progress 5, 6, and 7. At the end of the year, a new class of ferry craft with enhanced capabilities, named Soyuz-T, docked with the station as part of an unmanned exercise which lasted over 100 days.

During 1980, Progress 8 made an automated resupply flight to the unmanned station, followed by the manned Soyuz 35 with a crew that stayed up for 185 days. The long-duration team was visited by the Soyuz 36 crew, which included a Hungarian, and they traded Soyuz craft. Soyuz T-2 brought the next visiting Soviet crew up to the station in the first manned use of Soyuz T. Soyuz 37 carried up a visiting crew which included a Vietnamese, trading ships again to return to Earth in Soyuz 36. Soyuz 38 brought a visiting crew which included a Cuban, and then on October 11, the long-duration crew, originally sent up in Soyuz 35, came home in Soyuz 37. In November, Soyuz T-3 carried a three-man crew to the station on a 13-day flight, the first crew of that size since the ill-fated flight of Soyuz 11 back in 1971. During the year, three Progress flights (9, 10, and 11) resupplied the station.

Three more manned flights to Salyut 6 were accomplished during 1981. The Soyuz T-4 crew remained on-board for 75 days, and was visited by the crews of Soyuz 39 and Soyuz 40. These last two missions also completed the program of launching representatives of the Interkosmos countries, with Mongolian and Romanian cosmonauts respectively. The station was also resupplied by Progress 12 in 1981. The Soviets announced that Soyuz 40 was the last flight of the Soyuz spacecraft, which had been in service since 1967, and they would rely instead on the modified Soyuz T.

In June 1981, the unmanned spacecraft Kosmos 1267 docked with Salyut 6. The Soviets announced that its purpose was testing of a modular space station concept, and that Kosmos 1267 had life support systems on-board. Later, the Western press reported that Kosmos 1267 was in fact a "battle station" in orbit, armed with infrared homing devices. Salyut 6 and Kosmos 1267 were deorbited on July 29, 1982 while they were still docked. The full nature of Kosmos 1267's mission remains unclear, but probably was a modular space station test as the Soviets claimed.

2. Salyut 7

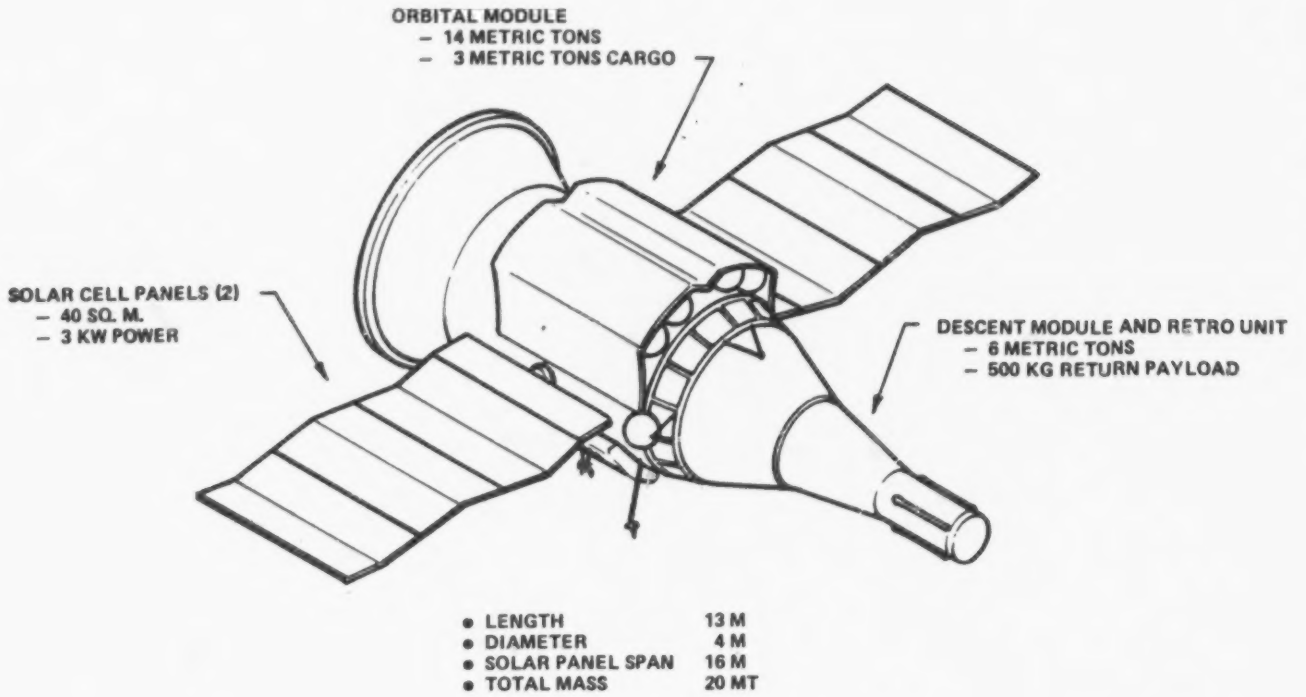
Salyut 7 was launched on April 19, 1982, the eleventh anniversary of the launch of Salyut 1. The space station is virtually identical to Salyut 6, although the Soviets report that it has an improved navigation system. The first crew, Soyuz T-5, was launched on May 13 and remained on board for 211 days, breaking the old record of 185 days set in 1980. Two crews visited the long-duration crew: Soyuz T-6 which included the first French "spationaut" and Soyuz T-7 which included the second woman to fly in space. There were four Progress resupply missions (13, 14, 15, and 16) in 1982.

In March 1983, the Soviets launched Kosmos 1443, which docked with Salyut 7 a week later. The Soviet press reported that this was an "operational" version of Kosmos 1267, and was a multipurpose vehicle which could be used as a cargo ship (with 2.5 times the capacity of Progress), a space tug, and/or a module to increase the habitable volume of the space station by 50 cubic meters. It also had a descent module for returning material to

Earth. A picture of the vehicle was published in Pravda and is shown in figure 1 (drawing by David Woods, IBM Federal Systems Division, Owego, N.Y.).

The first attempt to occupy the Salyut 7/Kosmos 1443 complex was unsuccessful when the Soyuz T-8 crew was unable to dock. In June, the Soyuz T-9 crew achieved a successful docking, and, once aboard, began unloading Kosmos 1443. Afterwards, Kosmos 1443 was separated from Salyut, and the descent module returned to Earth while the main part burned up in the atmosphere. On September 26, the Soviets attempted to launch the Soyuz T-10 crew, but a fire developed in the launch vehicle and the crew was jettisoned from the launch pad using the Soyuz emergency escape system, the first time this procedure has actually been used in either the U.S. or Soviet program. The two men (both of whom were also members of the failed T-8 crew) were rescued safely. It is generally thought that this crew would have replaced, rather than simply visited, the T-9 crew. Instead, the T-9 crew remained on board, and on November 1 and 3 conducted EVAs to install additional solar panels on the space station by attaching them to the existing arrays. The additional power is required for the experiments conducted on board. The T-9 crew returned in November 1983, after remaining in space for 149 days. In addition to Kosmos 1443, two Progress missions (17 and 18) resupplied the station.

FIGURE 1: Kosmos 1443 Spacecraft


ORBITAL MODULE
– 14 METRIC TONS
– 3 METRIC TONS CARGO
SOLAR CELL PANELS (2)
– 40 SQ. M.
– 3 KW POWER
DESCENT MODULE AND RETRO UNIT
– 6 METRIC TONS
– 500 KG RETURN PAYLOAD
• LENGTH 13 M
• DIAMETER 4 M
• SOLAR PANEL SPAN 16 M
• TOTAL MASS 20 MT
© D.R.Woods 1983

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D. REUSABLE SPACE VEHICLES

1. The U.S. Space Shuttle

NASA made its principal development program for the 1970s the creation of a reusable shuttle spacecraft to act as a ferry from Earth to orbit and return. Over a period of time, various configurations had been studied. The favored design for a period was for two completely resuable piloted stages. The booster stage would have been roughly the size of a 747 or C-5A; and the orbital stage about the size of a DC-8 or 707. Both were to be rocket-powered, burning hydrogen and oxygen. After a vertical takeoff with the two craft attached in parallel, the booster would have flown back to the launch site to be readied for the next trip. The upper stage was to fly on to orbit, and later return for reuse. Both stages were to land horizontally like aircraft. Analysis showed that although these craft represented an economical combination in the long run, they involved cost-peaking problems during development which made their fiscal and political practicability questionable.

The plan finally proposed in early January 1972 traded off some reusability for annual development cost totals which could be given consideration within the kind of budget ceilings with which NASA has worked in recent years. This compromise offered fewer cost savings in flight operations, but was believed by NASA to represent the only approach which was feasible under existing fiscal conditions. It was hoped by the sponsors that the booster stage could be replaced later by a fully reusable design. What has been built

is a reusable orbital stage about the size of a DC-9, powered by three hydrogen-oxygen engines from fuel contained in large external disposable and non-recoverable fuel tank. Two strap-on solid-fuel rockets are also used, which are jettisoned into the ocean and recovered for refurbishment and reuse. The shuttle can carry payloads measuring up to 4.6 meters in diameter by 18.3 meters long, and weighing up to 29,480 kilograms. It can accommodate a crew of two, plus up to five additional passengers, with a flight environment which would not require the special training and stresses of previous astronaut flight. Initially, the shuttle can remain in orbit for 7 days although this may be lengthened to 30 days if additional power supplies are available. Its tasks will include ferrying people and supplies, supporting an attached Spacelab, launching other satellites, and potentially even acting as a rescue ship. The shuttle may be used to service other spacecraft in orbit, perhaps bringing them back to Earth for major overhaul if required.

The first space shuttle flight was successfully accomplished on April 12, 1981, and was followed by three more orbital test flights (one in 1981, two in 1982). The first operational launch of the shuttle took place on November 11, 1982, and was used to place two communications satellites into geostationary orbit. This was also the first time a four-man crew was launched.

During 1983, four shuttle missions were launched, the first time in ten years that the number of U.S. manned flights exceeded those of the Soviets. The first for the year, STS-6, placed one of NASA's new Tracking and Data Relay Satellites (TDRS) in space, although the upper stage failed and placed TDRS into an improper orbit. Using the spacecraft's stationkeeping thrusters, ground controllers were able to nudge it into a usable orbit over a period

of several months. STS-7 took the first U.S. woman in space, and the crew deployed two communications satellites (one for Indonesia, one for Canada). This was the first five-person crew. STS-8 included the first U.S. black to go into space, and the crew deployed a communications satellite for India. STS-9 was the first flight of the European-built Spacelab, which flies in the cargo bay of the orbiter. This was the first six-person crew and included the first non-American to fly on an American manned mission (a West German). More than 70 experiments were conducted on the Spacelab 1 mission over a ten day period of time. The landing of this mission was delayed by eight hours because two of the five computers on the shuttle failed.

2. Soviet Development of a Spaceplane and Shuttle

Speculation has existed for many years that the Soviet Union is developing a reusable space shuttle vehicle. During the late 1970s, there were unconfirmed reports that drop tests of a shuttle vehicle had been made from aircraft and that a space launch could be expected soon.

An operational launch has not yet taken place, although in 1982, an unusual Soviet satellite, Kosmos 1374, was rumored to have been a test of a scale-model of a reusable spacecraft. Kosmos 1374 made only one and a quarter orbits and landed in the Indian Ocean where it was recovered by a Soviet fleet. Another unusual aspect of the flight is that it was launched from the Kapustin Yar launch site which is ordinarily used for small scientific and international cooperative missions, but not for man-related development programs.

In March 1983, the U.S. Department of Defense released an update of its 1981 Soviet Military Power report which stated that the Soviets are developing

two reusable shuttle vehicles: one similar to the U.S. shuttle, and a smaller "space plane." According to the DOD report, orbital test flights of the smaller vehicle had already occurred, a possible reference to Kosmos 1374.

A very similar mission was flown in March 1983, Kosmos 1445, and this time the Australians released several pictures of the vehicle as it was being recovered from the Indian Ocean by a Soviet fleet. Figure 2 shows the vehicle on the deck of a recovery ship, and tiles similar to the thermal protection tiles used on the U.S. shuttle can be seen. Figure 3 shows the underside of the vehicle, which appears smooth, suggesting that it may be covered with a carbon-carbon coating such as that used on the shuttle's nose. In December 1983, a third mission of this type of was flown, Kosmos 1517, only this time it made a "controlled descent" into the Black Sea, rather than the Indian Ocean. This test established a pattern of flights at 9 month intervals, and suggested growing confidence in the system by the Soviets.

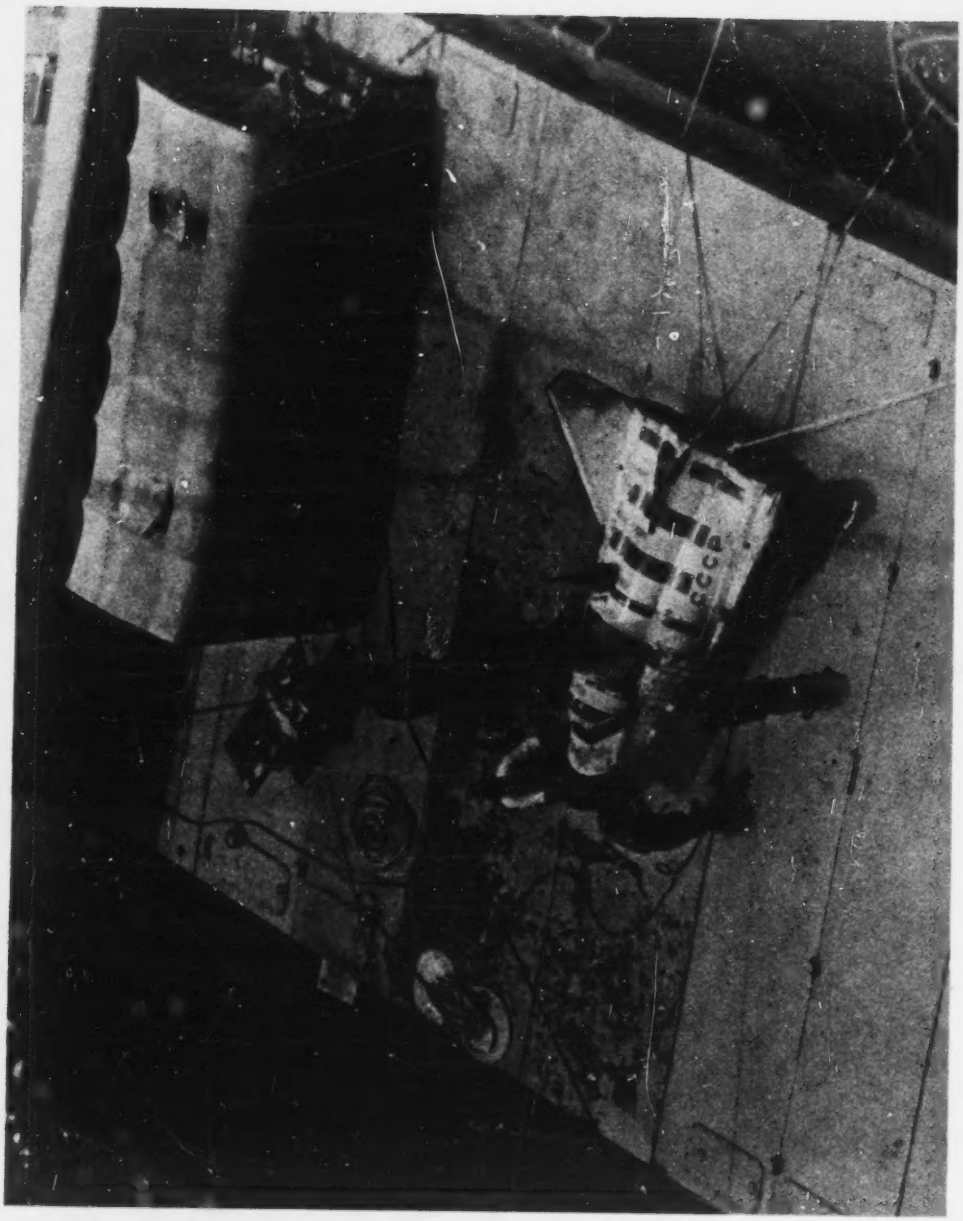
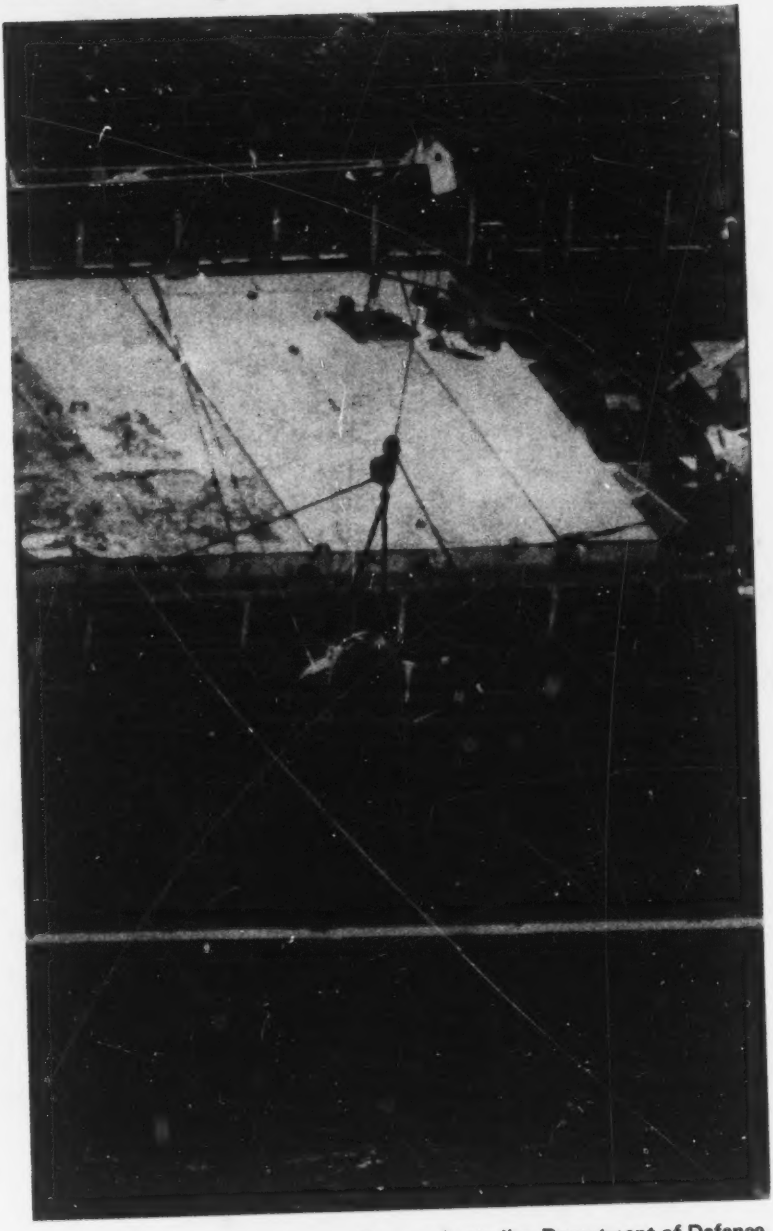


FIGURE 2: Kosmos 1445 Aboard Soviet Recovery Ship

FIGURE 3: Kosmos 1445 Being Taken Aboard Soviet Recovery Ship

Recovery of Kosmos 1445



Source: Australian Department of Defence.

TABLE 3. Summary List of Manned Space Flights

Launch Date	Vehicle Name	Crew	Weight (kgs)	Ship Duration (hrs.,min.)	Crew Duration (hrs.,min.)	Orbits	National Cumulative Personhours
1961							
Apr. 12	Vostok 1	Gagarin	4,725	1:48	same	1	1:48
May 5	MR-3	Shepard	1,290	:15	same	--	:15
July 21	MR-4	Grissom	1,286	:16	same	--	:31
Aug. 6	Vostok 2	Titov	4,731	25:18	same	17	27:06
1962							
Feb. 20	MA-6	Glenn	1,355	4:55	same	3	5:26
May 24	MA-7	Carpenter	1,349	4:56	same	3	10:22
Aug. 11	Vostok 3	Nikolayev	4,722	94:22	same	64	121:28
Aug. 12	Vostok 4	Popovich	4,728	70:57	same	48	192:25
Oct. 3	MA-8	Schirra	1,373	9:13	same	6	19:35
1963							
May 15	MA-9	Cooper	1,376	34:20	same	23	53:55
June 14	Vostok 5	Bykovskiy	4,720	119:06	same	81	311:31
June 16	Vostok 6	Tereshkova	4,713	70:50	same	48	382:21
1964							
Oct. 12	Voskhod 1	Komarov Yegorov Feoktistov	5,320	24:17	same	16	455:12
1965							
Mar. 18	Voskhod 2	Belyayev Leonov	5,682	26:02	same	17	507:16
Mar. 23	GT-3	Grissom (2) Young	3,225	4:53	same	3	63:41
June 3	GT-4	McDivitt White	3,574	97:56	same	66	259:33
Aug. 21	GT-5	Cooper (2) Conrad	3,605	190:55	same	128	641:23
Dec. 4	GT-7	Borman Lovell	3,663	330:35	same	220	1,302:33
Dec. 15	GT-6	Schirra (2) Stafford	3,546	25:51	same	17	1,354:15

TABLE 3. Summary List of Manned Space Flights--continued

Launch Date	Vehicle Name	Crew	Weight (kgs)	Ship Duration (hrs.,min.)	Crew Duration (hrs.,min.)	Orbits	National Cumulative Perscnhours
1966							
Mar. 16	GT-8	Armstrong Scott	3,788	10:41	same	7	1,375:37
June 3	GT-9	Stafford (2) Cernan	3,750	72:21	same	47	1,520:19
July 18	GT-10	Young (2) Collins	3,741	70:47	same	46	1,661:53
Sept. 12	GT-11	Conrad (2) Gordon	3,860	71:17	same	47	1,804:27
Nov. 11	GT-12	Lovell (2) Aldrin	3,763	94:35	same	63	1,993:37
1967							
Jan. 27	AS-204	Grissom (3) 1/ White (2) 1/ Chaffee 1/		[Not a space flight, but date of fatal fire on pad during test preliminary to later scheduled flight.]			
Apr. 23	Soyuz 1	Komarov (2) 1/	20,412 6,450	26:48	same	18	534:04
1968							
Oct. 11	Apollo 7	Schirra (3) Eisele Cunningham	20,569	260:09	same	174	2,774:04
Oct. 26	Soyuz 3	Beregovoy	6,575	94:51	same	64	628:55
Dec. 21	Apollo 8	Borman (2) Lovell (3) Anders	43,663	147:01	same	2(Earth) 10 (Moon)	3,215:07
1969							
Jan. 14	Soyuz 4	Shatalov (Yeliseyev) (Khrunov)	6,625	71:21	same	48	795:54
Jan. 15	Soyuz 5	Volynov Yeliseyev Khrunov	6,585	72:54	same for 1 47:49 for 2	49	868:48

1/ Fatality

TABLE 3. Summary List of Manned Space Flights--continued

Launch Date	Vehicle Name	Crew	Weight (kgs)	Ship Duration (hrs.,min.)	Crew Duration (hrs.,min.)	Orbits	National Cumulative Personhours
Mar. 3	Apollo 9	McDivitt (2) Scott (2) Schweickart	43,185	241:01	same	162	3,938:10
May 18	Apollo 10	Stafford (3) Young (3) Cernan (2)	48,638	192:03	same	2 (Earth) 31 (Moon)	4,514:19
July 16	Apollo 11	Armstrong (2) Collins (2) Aldrin (2)	49,698	195:19	same	2 (Earth) 30 (Moon)	5,100:16
Oct. 11	Soyuz 6	Shonin Kubasov	6,577	118:43	same	80	1,106:14
Oct. 12	Soyuz 7	Filipchenko Gorbatko Volkov	6,570	118:40	same	80	1,462:14
Oct. 13	Soyuz 8	Shatalov (2) Yeliseyev (2)	6,646	118:51	same	80	1,699:56
Nov. 14	Apollo 12	Conrad (3) Gordon (2) Bean	49,804	244:36	same	2 (Earth) 45 (Moon)	5,834:04
1970							
Apr. 11	Apollo 13	Lovell (4) Haise Swigert	49,990	142:55	same	2 (Earth) 1 (Moon)	6,262:49
June 1	Soyuz 9	Nikolayev (2) Sevastyanov	6,500	424:59	same	286	2,549:54
1971							
Jan. 31	Apollo 14	Shepard (2) Roosa Mitchell	46,347	216:02	same	2 (Earth) 34 (Moon)	6,910:55
Apr. 19	Salyut	(Occupied by Soyuz 11 crew)	18,600?	---		---	---

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TABLE 3. Summary List of Manned Space Flights--continued

Launch Date	Vehicle Name	Crew	Weight (kgs)	Ship Duration (hrs.,min.)	Crew Duration (hrs.,min.)	Orbits	National Cumulative Personhours
Apr. 22	Soyuz 10	Shatalov (3) Yeliseyev (3) Rukavishnikov	6,575?	47:46	same	32	2,693:12
June 6	Soyuz 11	Dobrovolskiy 1/ Volkov (2) 1/ Patsayev 1/	6,575?	570:22	same	385	4,404:18
July 26	Apollo 15	Scott (3) Irwin Worden	52,759	295:12	same	2 (Earth) 74 (Moon)	7,796:31
1972							
Apr. 16	Apollo 16	Young (4) Duke	51,571	265:51	same	2 (Earth) 65 (Moon)	8,594:04
Dec. 7	Apollo 17	Cernan (3) Schmitt Evans	51,808	301:52	same	3 (Earth) 75 (Moon)	9,499:40
1973							
May 14	Skylab 1	(Occupied by Skylab 2,3 & 4 crews)	89,439	---		---	---
May 25	Skylab 2	Conrad (4) Kerwin Weitz	30,803	672:50	same	433	11,518:10
July 28	Skylab 3	Bean (2) Garriott Lousma	30,694	1,427:09	same	919	15,799:37
Sept. 27	Soyuz 12	Lazarev Makarov	6,575?	47:16	same	32	4,498:50
Nov. 16	Skylab 4	Carr Gibson Pogue	31,232	2,017:16	same	1,298	21,851:25
Dec. 18	Soyuz 13	Klimuk Lebedev	6,575?	188:56	same	127	4,876:42

1/ Fatality

TABLE 3. Summary List of Manned Space Flights--continued

Launch Date	Vehicle Name	Crew	Weight (kgs)	Ship Duration (hrs.,min.)	Crew Duration (hrs.,min.)	Orbits	National Cumulative Personhours
1974							
June 24	Salyut 3	(Occupied by Soyuz 14 crew)	18,900?	---		---	---
July 3	Soyuz 14	Popovich (2) Artyukhin	6,570?	337:30	same	252	5,631:42
Aug. 26	Soyuz 15	Sarafanov Demin	6,570?	48:12	same	32	5,728:06
Dec. 2	Soyuz 16	Filipchenko (2) Rukavishnikov (2)	6,570?	142:24	same	96	6,012:54
Dec. 26	Salyut 4	(Occupied by Soyuz 17, 18 crews)	18,900	---		---	---
1975							
Jan. 10	Soyuz 17	Gubarev Grechko	6,570?	709:20	same	466	7,431:34
Apr. 5	Anomaly	Lazarev (2) Makarov (2)	6,570?	:20	same	---	7,432:14
May 24	Soyuz 18	Klimuk (2) Sevastyanov (2)	6,570?	1,511:20	same	993	10,454:54
July 15	Soyuz 19	Leonov (2) Kubasov (2)	6,800	142:31	same	96	10,739:56
July 15	Apollo	Stafford (4) Slayton Brand	14,743	217:28	same	145	22,503:49
1976							
June 22	Salyut 5	(Occupied by Soyuz 21, 24 crews)	18,900?	---		---	---
July 6	Soyuz 21	Volynov (2) Zholobov	6,570?	1,182:23	same	790	13,104:42
Sept. 15	Soyuz 22	Bykovskiy (2) Aksenov	6,570?	189:52	same	127	13,484:26
Oct. 14	Soyuz 23	Zudov Rozhdestvenskiy	6,570?	48:07	same	32	13,580:40

TABLE 3. Summary List of Manned Space Flights--continued

Launch Date	Vehicle Name	Crew	Weight (kgs)	Ship Duration (hrs.,min.)	Crew Duration (hrs.,min.)	Orbits	National Cumulative Personhours
1977							
Feb. 7	Soyuz 24	Gorbatko (2) Glazkov	6,570?	425:26	same	285	14,431:32
Sept. 29	Salyut 6	(Occupied by Soyuz 26, 27, 28, 29, 30, 31, 32, 35, 36, 37, 38, T2, T3, T4, 39, 40 crews)	18,900?	---		---	---
Oct. 9	Soyuz 25	Kovalenok Ryumin	6,570?	48:45	same	32	14,529:02
Dec. 10	Soyuz 26	Romanenko Grechko (2)	6,570?	898:06	2314:00	590	19,157:02
1978							
Jan. 10	Soyuz 27	Dzhanibekov Makarov (3)	6,570?	1,558:53	142:59	1,024	19,443:00
Mar. 2	Soyuz 28	Gubarev (2) Remek (Czechoslovakia)	6,570?	190:16	same	125	19,823:32
Jun. 15	Soyuz 29	Kovalenok (2) Ivanchenkov	6,570?	1,911:23	3350:48	125	26,525:08
Jun. 27	Soyuz 30	Klimuk (3) Hermaszewski (Poland)	6,570?	190:03	same	125	26,905:14
Aug. 26	Soyuz 31	Bykovskiy (3) Jahn (German Dem. Rep.)	6,570?	1,628:14	188:49	1,070	27,282:52

TABLE 3. Summary List of Manned Space Flights--continued

Launch Date	Vehicle Name	Crew	Weight (kgs)	Ship Duration (hrs.,min.)	Crew Duration (hrs.,min.)	Orbits	National Cumulative Personhours
1979							
Feb. 25	Soyuz 32	Lyakhov Ryumin (2) (Returned unmanned)	6,570?	2,596:24	4,200:36	1,711	35,684:04
Apr. 10	Soyuz 33	Rukavishnikov (3) Ivanov (Bulgaria)	6,570?	47:01	same	31	35,778:06
June 6	Soyuz 34	(Launched unmanned, returned Soyuz 32 crew)	6,570?	1,770:17	0	1,153	---
1980							
Apr. 9	Soyuz 35	Popov Ryumin (3)	6,570?	1,321:29	4,436:12	868	44,650:30
May 26	Soyuz 36	Kubasov (3) Farkas (Hungary)	6,570?	1,580:54	188:46	1,040	45,028:02
June 5	Soyuz T-2	Malyshev Aksenov (2)	7,000?	94:19	same	62	45,216:40
July 23	Soyuz 37	Gorbatko (3) Pham Tuan (Viet Nam)	6,570?	1,911:17	188:42	1,257	45,594:04
Sept. 18	Soyuz 38	Romanenko (2) Tamayo Mendez (Cuba)	6,570?	188:43	same	124	45,971:30
Nov. 27	Soyuz T-3	Kizim Makarov (4) Strekalov	7,000?	307:08	same	204	46,892:54

TABLE 3. Summary List of Manned Space Flights--continued

Launch Date	Vehicle Name	Crew	Weight (kgs)	Ship Duration (hrs.,min.)	Crew Duration (hrs.,min.)	Orbits	National Cumulative Personhours
1981							
Mar. 12	Soyuz T-4	Kovalenok (3) Savinykh	7,000?	1,794:38	same	1,196	50,482:10
Mar. 22	Soyuz 39	Dzhanibekov (2) Gurragcha (Mongolia)	6,570?	188:43	same	125	50,859:36
Apr. 12	STS 1	Young (5) Crippen	98,658	54:21	same	36	22,612:31
May 14	Soyuz 40	Popov (2) Prunariu (Romania)	6,570?	188:41	same	126	51,236:58
Nov. 12	STS 2	Engle Truly	103,811	54:13	same	36	22,720:57
1982							
Mar. 22	STS 3	Lousma (2) Fullerton	106,000	192:05	same	128	23,105:07
Apr. 19	Salyut 7	(Occupied by Soyuz T-5, T-6, T-7,T-9 crews)	18,900?	--		--	--
May 13	Soyuz T-5	Berezovoy Lebedev (2)	7,000?	2,549:06	5,073:05	1,690	61,383:08
June 24	Soyuz T-6	Dzhanibekov (3) Ivanchenkov (2) Chretien (France)	7,000?	189:51	same	126	61,952:41
June 27	STS-4	Mattingly (2) Hartsfield	108,797	169:10	same	112	23,443:27
Aug. 19	Soyuz T-7	Popov (3) Serebrov Savitskaya	7,000?	2,712:51	189:52	1,800	62,522:17
Nov. 11	STS-5	Brand (2) Overmyer Allen Lenoir	111,201	122:14	same	82	23,932:23

TABLE 3. Summary List of Manned Space Flights--continued

Launch Date	Vehicle Name	Crew	Weight (kgs)	Ship Duration (hrs.,min.)	Crew Duration (hrs.,min.)	Orbits	National Cumulative Personhours
1983							
Apr. 4	STS-6	Weitz (2) Bobko Musgrave Peterson	251,813	120:24	same	80	24,413:59
Apr. 20	Soyuz T-8	Titov Strekalov (2) Serebrov (2)	7,000?	48:18	same	32	62,667:11
June 18	STS-7	Crippen (2) Hauck Ride Fabian Thagard	244,031	146:24	same	98	25,145:59
June 27	Soyuz T-9	Lyakhov (2) Alexandrov	7,000?	3,585:46	same	2,391	69,838:43
Aug. 30	STS-8	Truly (2) Brandenstein Thornton Bluford Gardner	230,808	145:09	same	97	25,871:44
Sept. 26	(Soyuz T-10)	Titov (2) Strekalov (3)	(Not a spaceflight. Crew jettisoned using emergency abort system after fire erupted in launch vehicle prior to launch)				
Nov. 28	STS-9	Young (6) Shaw Parker Garriott (2) Lichtenberg Merbold (W. Germany)	242,578	247:47	same	165	27,358:26

CHAPTER THREE: SPACE APPLICATION FLIGHTS

In the area of space applications, the United States has held a clear lead from the early days of the space program, and this experience has permitted this country to move ahead to more advanced systems while the Soviet Union is still working hard to catch up.

A. COMMUNICATIONS

The United States experimented with both civilian and military communication satellites, first with low-altitude pickup, tape storage, and replay systems, and also with passive reflectors of the balloon type. Beginning in 1963, the United States began placing communications satellites, of increasing capacity each year, in geosynchronous orbit at 35,880 kilometers altitude above the Equator. A satellite in this orbit will maintain a fixed postition relative to the ground. Color TV can be relayed across oceans, and telephone and data relay capacity is growing rapidly, with a matching drop in costs of operation.

The Soviet Union started along quite a different path using satellites in highly elliptical rather than geosynchronous orbits. Since 1965, the Russians have put up a series of Molniya 1 satellites which fly in an orbit inclined at 63 degrees to the Equator with a low point over the southern hemisphere, but a long linger time at the peak of the orbit in the northern hemisphere, so that each is in view of major Soviet ground terminals for about 8 hours a day, including those at near polar latitudes harder to reach with equatorial satellite systems. Their high power has permitted the establishment

of relatively low-cost terminals to distribute TV programs from Moscow to outlying points, as well as carrying telephone and computer data traffic. By proper spacing of eight of these satellites in 12-hour semisynchronous orbits in orbital planes 45 degrees apart, it is possible to give full daily coverage, with each satellite traveling the same ground trace each day.

The Molniya 1's have been partially relegated to military service. They were followed first by Molniya 2 and then by Molniya 3 satellites (four to a system) using higher frequencies to provide the prime service, arranged in planes 90 degrees apart.

In 1974 the Russians placed their first geosynchronous satellite in orbit, Kosmos 637, followed by Molniya 1S-1. Late in 1975, the Soviets announced plans for a series of geosynchronous satellites which will occupy eleven "Statsionar" positions. Raduga, the first of these, was launched on December 22, 1975. It was followed in 1976 by a new system, Ekran, for transmitting television to small antennas located primarily in Siberia. In 1978, a third system, called Gorizont, was introduced.

Two geosynchronous satellites with experimental systems were launched in 1982: Gorizont 5, which in addition to its regular transponders in the 6/4 GHz band, carried new Luch transponders which operate in the 14/11 GHz range, and Volna transponders for maritime use; and Kosmos 1366 which the Soviets reported was performing tests in the SHF range.

Military communications systems within the Kosmos program also are in place for theater tactical use and in store-dump mode worldwide. (Store-dump satellites receive messages, place these on tape, and replay them later on command.)

B. WEATHER REPORTING

The United States has an operational weather satellite system using the NOAA series in polar orbits and GOES satellites in geosynchronous orbits. World coverage is fairly good, including the ability of local stations to read the APT (automatic picture transmission) equipment on board many of these satellites for a "real time" view of local regional weather. There are also military weather satellites in orbit.

The Soviet Union also came late to this field compared with the United States. Only since 1966 have they distributed satellite-gathered weather pictures, and these spacecraft have had the disadvantage of a shorter useful life before electronic failure, compared to United States spacecraft. Their pictures have a higher resolution which may give more detail, but high resolution reduces the amount of daily coverage a satellite can give, with many smaller area pictures having to be fitted together for larger area views. On the other hand, the Soviet satellites more nearly resemble advanced U.S. Nimbus craft in terms of the wider variety of sensors carried and the experimental work underway which may open up new discoveries. In 1977, for the first time, a Soviet weather satellite was put into a retrograde, Sun-synchronous orbit (to take pictures at a constant local time), the pattern long favored for U.S. weather satellites. In addition to these Meteor weather satellites of lower altitude flights, weather cameras have been carried on some of the higher flying Molniya 1 satellites as well, so that a steerable camera at 40,600 kilometers can give wide area views like those taken by the U.S. craft at similar altitudes. The Soviets had promised to provide a 24-hour synchronous weather satellite for the cooperative world system being created with the United States, Japan and Western Europe, but the flight has been delayed indefinitely.

C. NAVIGATION AND TRAFFIC CONTROL

The United States has a U.S. Navy operational navigation satellite system, originally called Transit, now renamed the Navy Navigation Satellite System. It operates through the passive reading on ships of Doppler shift in harmonic signals from the satellites, and the data are manipulated by a computer on board the ship in connection with broadcast data on the position of the satellite. Two-dimensional data (latitude and longitude) are provided. It is not particularly suited to commercial economics, but it is highly effective for naval purposes. Commercial ships have been permitted to use the same system since 1967 if they care to invest in the necessary computer equipment. An improved version of Transit, called Nova, is now coming into use with the first launch in 1981.

An even more ambitious global positioning system, ultimately to use 18 satellites, began operations in 1978 with the first four NAVSTAR satellites. This system provides three-dimensional (latitude, longitude, and altitude) data. Two more NAVSTARS were launched in 1980, but a launch attempt in 1981 failed because of a launch vehicle malfunction. Another NAVSTAR launch was successfully accomplished in 1983. These satellites are part of the NAVSTAR development program; the system is not expected to be operational until 1988. Future civilian systems are more likely to require the ship or aircraft to play an active role by broadcasting signals to satellites, which will relay to a shorebased computer these data to find the ship or aircraft position, and this may serve in future traffic control systems as well. This has been tested in the ATS satellites.

The Soviet Union claims to have had an operational navigation satellite system for many years, but waited until 1978 to identify the first specific component, Kosmos 1000. A new label was applied at the Paris Air Show Soviet display of a navigation satellite--Tsikada. However, many of the Kosmos missions are flown in ways which strongly suggest these are navigation satellites, probably linked with a passive ship system for naval purposes, which would seem a close parallel to the Transit system of the United States, even to using the same radio frequencies. In 1982, the Soviets placed three GLONASS satellites into orbit with a single launch. This system is expected to be similar to NAVSTAR when it is operational, but it is speculated in the West that this first launch was a partial failure. Two more GLONASS launches, placing six satellites in orbit, were accomplished in 1983.

D. GEODESY AND MAPPING

The United States has flown many geodetic flights in the interest of tying together maps of different parts of the world and for basic scientific studies to understand better the true shape of the world. If there have been mapping flights as well, the results have not been published.

The Soviet Union professes an interest in both geodesy and mapping, but too few findings have been made available to judge how far along they are in comparison with the United States. Some known Kosmos flights have the right characteristics to support such missions.

E. EARTH RESOURCES

One of the most exciting new fields of space application is that of finding and managing Earth resources in many fields through use of satellites. It is expected that mineral deposits and oil fields can be found, and forest fires located. The location of diseased trees and agricultural crops may be identified, censuses of crops taken, snowfall and water status reported, fisheries run more efficiently, and many other similar practical things done from space. The United States has now flown Landsat 1, 2, 3, and 4 and also Seasat and HCMM to conduct such experiments.

The Soviet Union has expressed a similar interest. Certain Soyuz flights and the Salyut stations were announced as having explored data-gathering techniques for Earth resources purposes. During 1977, two short-life recoverable Kosmos flights at 82.3 degrees were specifically identified as doing Earth-resources work, as were two in 1978. These launches have continued since that time.

The Soviets are also experimenting with advanced sensors for earth resources sensing in the Meteor 2 series of flights. In 1983, in addition to the two-week satellites at 82.3 degrees, the Soviets launched what may be the first of a new series of remote sensing satellites. Placed in a sun-synchronous orbit, it was given only a Kosmos designation (K 1484), and no other details were given.

CHAPTER FOUR: SPACE SCIENCE

Both the United States and the Soviet Union have sent probes to fly-by, orbit, and/or land on other planets. So far, the United States has sent probes to Mercury, Venus, the Moon, Mars, Jupiter, and Saturn, and one is now enroute to Uranus. The Soviet Union has sent probes to Venus, the Moon, and Mars.

A. EARTH-ORBITAL SPACE SCIENCE

The history of earth orbiting satellites for space science studies began with the very first launches of spacecraft. As discussed at the beginning of this report, the decision to launch satellites was initially made as part of the International Geophysical Year (IGY), and both Sputnik 1 and Explorer 1 were launched in support of the IGY.

The United States has conducted a large number of launches for earth orbiting space science missions. The Explorer program is a series of small satellites devoted to a particular scientific goal (such as gamma ray astronomy). If successful, the sensors may be adapted and flown on larger, observatory-class satellites. Many of the Explorer missions involve international participation.

By the end of 1983, over 60 Explorer satellites had been flown. Some study the interaction between the sun and Earth in disciplines such as air

density, energetic particles, geodesy, ionospheric research, magnetospheric research, and solar physics. Other Explorer satellites are dedicated to astronomy, including wavelengths in the x-ray, gamma-ray, ultraviolet, and radio ranges. In 1983, NASA launched the InfraRed Astronomy Satellite (IRAS), a cooperative project between the United States, the Netherlands, and Britain, as part of the Explorer program. This satellite required super-cold sensors to seek out sources of infrared radiation in space, and thus operated only as long as there was sufficient coolant to maintain the sensors at a temperature of -455 degrees F. The coolant supply was exhausted in November of 1983. Preliminary results from IRAS suggest that there may be solar systems around two other planets, Vega and Fomalhaut, the first time scientists have had empirical evidence that Earth may not be unique.

Larger observatory-class satellites have also been launched by the United States. To date, these have included the Orbiting Geophysical Observatory (OGO), Orbiting Solar Observatory (OSO), Orbiting Astronomical Observatory (OAO), and High Energy Astronomy Observatorty (HEAO) programs. Nine satellites in the OSO series were launched from 1962 to 1975; six in the OGO series from 1964 to 1969; three in the OAO series from 1966 to 1972 (although one did not operate once in orbit); and three in the HEAO series from 1977 to 1979. The next U.S. observatory-class spacecraft is the Space Telescope, which will be the first optical telescope in orbit, and is scheduled for launch in 1986. NASA is also planning a Gamma Ray Observatory for launch in 1988.

The Soviet Union has taken much longer to use earth orbit as a base for free-flying scientific missions. Although they have launched Explorer-class satellites in the Kosmos and Interkosmos series for many years, they

all seem to have had similar missions related to studying the Earth's atmosphere, rather than the broad array of missions in the Explorer series. They launched four Proton satellites in the 1965-1968 time period to study cosmic rays, but although these were large satellites, it is generally thought in the West that the true objective was to test the new launch vehicle which placed these satellites in orbit (the "D" or Proton vehicle), rather than to acquire scientific data.

The Prognoz program, of which there have been nine flights since 1971, is the closest the Soviets have come to an observatory-class spacecraft. The first eight of these, however, again concentrated on atmospheric studies. The most recent of these, Prognoz 9, launched in 1983, reflected a new use of this type of spacecraft: it is performing radio astronomy studies. The Soviets placed the first radio telescope in earth orbit on Salyut 6. The crew operated the telescope for only three weeks, however, and the data reportedly were not very good (the telescope's dish antenna may not have opened fully).

Also in 1983, the Soviets launched the ASTRON satellite, which is a large observatory-class satellite performing research in the x-ray and ultraviolet wavelengths.

Space science research has also been conducted on the space stations launched by both the United States and Soviet Union. For example, the U.S. Skylab carried the Apollo Telescope Mount dedicated to studies of the Sun, and as noted above, Salyut 6 deployed a radio telescope. Astronomical studies were conducted on Salyut 1 and 4, and to a small extent on Salyut 7.

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B. MOON FLIGHTS, LUNA 1-3 VS. PIONEER AND RANGER

In 1958, the United States began a double series of Pioneer flights--one to photograph the far side of the Moon and the other to fly by it. All four launch attempts in that year failed to reach the Moon. In January 1959, the Russians launched Luna 1 which sent 361 kilograms past the Moon (apparently a miss) to circle the Sun. The U.S. National Aeronautics and Space Administration (NASA) followed in March 1959 with its 6 kilogram Pioneer 4 which went by the Moon and circled the Sun. U.S. plans then were to follow up with four more, larger Pioneer series lunar orbit flights during the course of 1959 and 1960, but all of these failed to reach even Earth orbits. In fact, NASA did not reach the Moon until an early Ranger fell on the far side of the Moon (Ranger 4 in 1962). In September 1959, the Soviet Luna 2 struck the Moon near its visible center, delivering metal plaques bearing the Soviet coat of arms. Luna 3 in October 1959 flew by the Moon and by automatic means tooks photographs of the far side, never seen before, which were returned to Earth by radio facsimile. Still later, the U.S. Ranger 7, 8, and 9 flights in 1964-1965 returned spectacular TV pictures of the Moon up to the moment of impact.

C. SURVEYOR AND LUNAR ORBITER VS. LUNA 4-14

In 1963, both the United States and the Soviet Union planned to land survivable payloads on the Moon. The U.S. program was called Surveyor, and although it did not fly until 1966, it was a very great success. The several Surveyors which landed intact returned close to 100,000 pictures of their immediate surroundings and dug holes in the surface by remote control and determined the chemical composition of the lunar soil by an indirect means.

By contrast, the Soviet Union started landing attempts in 1963, but later admitted that Luna 4, 5, 6, 7, and 8 failed to achieve a survivable landing. Additionally, one unnamed flight and Kosmos 60 were lunar failures which did not leave Earth orbit. When Luna 9 in 1966 finally made it to the surface, the landing was not as gentle as a Surveyor landing, and the television camera returned only 27 pictures of the surroundings. Luna 13 additionally did impact testing of the soil with an extendable arm.

This comparison shows how difficult it can be to draw a balance sheet between two programs. U.S. Surveyors were more impressive than the Soviet Luna ships. But along with this, one must also note that Luna 9 landed a working camera before the first Surveyor, and the 27 Soviet pictures essentially answered the basic questions about the surface of the Moon, even though these did not compare in number with the thousands of pictures from Surveyor.

In the case of orbiters there were also different comparisons to draw, but the total usefulness of the U.S. Lunar Orbiters seems hard to contest. The Soviet Luna 10 reached a successful orbit before the first U.S. Lunar Orbiter, and its indirect measure told the Russians something of the probable composition of the lunar surface and also about gravity anomalies. Luna 12 in 1966 finally returned a few pictures to supplement earlier Soviet pictures taken of the far side by Luna 3 in 1959 and Zond 3 in 1965. But in no real sense did the few score Soviet pictures from these flights come anywhere near the clarity, detail, and variety of the five sets of Lunar Orbiter views, each of which returned about 200 double frames (simultaneous views through narrow angle and wide angle lenses). The subsequent Luna 14 seems only to

have been an extension of the work of the non-picture-taking Luna 10. (Additional Soviet lunar orbiters are discussed in section D.)

Zond 5 and 6, the 1968 unmanned precursors to projected later manned flights, did better in picture quality because they returned actual photographs to Earth in the same manner as was done shortly thereafter by Apollo 8. Zond 7 in 1969 and Zond 8 in 1970 performed tasks similar to those of the two preceding Zonds.

D. SOVIET LUNAR SAMPLE RETURN FLIGHTS

In July 1969, the Russians sent Luna 15 to the Moon (using a large D class launch vehicle) at a time overlapping with the flight of Apollo 11. Its mission cannot be determined because it crashed during a soft landing attempt.

In 1970, Luna 16 maneuvered into lunar orbit, then landed, and by remote control bored a sample core 35 centimeters in length, weighing 101 grams, which was sealed in a container and rocketed back to Earth for recovery in the Soviet Union. Although the sample was small, it provided useful analytical material for a special quarantine laboratory similar to the Houston, Texas facility.

Luna 18, launched in 1971 on a similar mission, made a bad landing and was destroyed. Luna 20 in 1972 repeated the success of Luna 16, returning a sample from highlands, contrasted with the mare sample of its predecessor. Luna 23 in 1974 survived its landing, but its drill was damaged in landing, and after a few days the experiment was shut down without a sample return.

Luna 24 in 1976 was the most successful, being able to drill to a depth of 2 meters and returning all this sample core to Earth.

A total of 330 grams of lunar material was returned by the Soviet Luna spacecraft, compared with 380 kilograms returned by the U.S. Apollo crews.

E. SOVIET LUNAR SURFACE ROVING VEHICLES

Luna 17 was the first successful landing of a Lunokhod roving vehicle weighing 756 kilograms. After landing on November 17, 1970, it continued to function until October 4, 1971, traveling 10,540 meters over the surface, and returning 20,000 television views, 200 detailed panoramas, 500 soil-property tests, 25 soil chemical analyses, and a number of astronomical observations with its X-ray telescope.

Luna 21 in 1973 landed Lunokhod 2 (840 kilograms), which operated for 3 months, but traveled 37,000 meters in that time, and returned proportionately more data and pictures also, despite its shorter life than Lunokhod 1.

F. SOVIET LUNAR ORBITERS

The same D class launch vehicles used for the sample return and surface roamer missions was also used to place heavy payloads in lunar orbit in 1971 and 1974. Luna 19 was sent to the Moon in 1971, and remained under active control for about a year, gathering a wide variety of synoptic data and some pictures. Luna 22 in 1974 was a similar mission, remaining under active control for about a year and a half. During many maneuvers it was able to take high resolution pictures at some close approaches to the Moon.

G. U.S. PLANETARY MISSIONS

The U.S. Mariner program of three-axis stabilized probes has launched ten vehicles, of which six returned planetary data. Mariner 2 and 5 brought back indirect readings from Venus. Mariner 4, 6, 7, and 9 brought back increasingly good pictures of the surface features of Mars. Mariner 10 not only returned good pictures of the cloud patterns of Venus, but made three photographic passes by Mercury with good results.

The Pioneer series of spin-stabilized spacecraft has seen 18 launch attempts, of which 12 were at least partially successful. Pioneer 1 and 3 did not reach their intended trajectories to the Moon, but did send back data about Earth's atmosphere. Pioneer 4 successfully returned data as it flew past the Moon and entered heliocentric orbit. Pioneers 5 through 9 were designed to study the area of space between the Earth and Sun, and did so successfully. Pioneers 6, 7, 8, and 9, launched between 1965 and 1968, were still returning data at the end of 1981.

Pioneers 10 and 11 were the first planetary probes of the Pioneer series, and were launched to investigate Jupiter, Saturn, and the interplanetary medium. Both probes sent back pictures of Jupiter in 1973 and 1974 respectively; Pioneer 10 then was placed on a trajectory out of the solar system, while Pioneer 11 continued on to a successful encounter with Saturn in 1979. Pioneer 10 continues to return data, and in 1983 passed out of the solar system, the first object from planet Earth to do so.

Pioneer Venus 1 and 2 were launched in 1978 and reached Venus in December of that year. Pioneer Venus 1 is an orbiter, which at the end of

1983 was continuing to return data about Venus. The spacecraft carries a radar for studying surface features. Pioneer Venus 2 consisted of five separate probes, all of which descended through the Venusian atmosphere to make in situ measurements of its characteristics. Although they were not designed to withstand landings on the planet, two of the probes did survive and transmitted data for as long as 67 minutes after impact.

Viking 1 and 2, launched in 1975, each were orbiter/lander combinations. The orbiters mapped the surface of Mars and collected clear views of Deimos and Phobos. The landers sent back color pictures from the surface, and their on-board laboratories conducted a search for life with puzzling, inconclusive findings.

Voyager 1 and 2 were launched in 1977 toward Jupiter and the outer planets. During 1979 they returned astonishing color pictures not only of Jupiter but also of its larger moons, each unique and unexpected in appearance. Voyager 1 returned equally exciting pictures of Saturn, Titan, and other moons during 1980, and Voyager 2 returned additional data on Saturn in 1981. Voyager 2 is now enroute to Uranus with closest approach expected in 1986.

H. SOVIET PLANETARY MISSIONS

The commitment of payloads to planetary missions by the Russians has been much heavier than by the Americans, but with mixed results. Two Mars attempts as early as 1960 failed to reach even Earth orbit. In 1961, there were two Venus attempts, with Venera 1 reaching the vicinity of the planet in nonoperating condition. In 1962, there were three more Venus attempts and three Mars attempts, with five of these payloads stranded Earth orbit,

and Mars 1 in nonoperating condition when it reached the vicinity of that planet. Zond 1, Venera 2, and Venera 3 were not in operating condition when they reached Venus. Zond 2 made a close fly-by of Mars in nonoperating condition. Zond 3 was expended as a test flight taking pictures of the far side of the Moon and rebroadcasting these to Earth as it traveled as far as the orbit of Mars.

Results improved for the Russians when Venera 4, 5, 6, 7 and 8 all functioned to return direct readings within the atmosphere of Venus. Of these Venera 7 survived a Venus landing and broadcast for 23 minutes on the surface. Venera 8 had similar success, plus doing soil analyses.

As in the lunar program, the Russians shifted from use of the A class launch vehicle to the D class so that Venera 9 and 10 in 1975 accomplished the nearest Venus equivalent of American Viking missions to Mars. The orbital vehicles returned pictures and other data for many months in orbit. The landers operated about an hour on the surface, and their cameras returned good pictures of the far side surface, relayed via the orbiters. This was a remarkable feat, considering the 485 degrees C temperature.

Venera 11 and 12 were sent to Venus in 1978, at approximately the same time as the U.S. Pioneer-Venus probes. No photographs were returned by these spacecrafts, and Soviet scientists have told their U.S. counterparts that the imaging systems failed. Data was returned on other aspects of the Venusian atmosphere and surface. In late 1981, Venera 13 and 14 were launched, and they landed on March 1 and 5, 1982. The spacecraft sent back color photographs of the surface, and carried drills with which to obtain core samples for in situ chemical analysis.

In 1983, the Soviets launched Venera 15 and 16 which, instead of carrying the traditional landers, were equipped with radars to study the surface of Venus from orbit. Venera 15 entered orbit around Venus on October 10, followed four days later by Venera 16. The radars have a resolution of 1-2 kilometers, and are in polar orbits around the planet so provide data on parts of the planet not seen by the U.S. Pioneer-Venus orbiter.

In December 1984, the Soviets are scheduled to launch two VEGA spacecraft, which will study both Venus and Halley's comet. At Venus, the two spacecraft will drop off landers, and balloons developed by French scientists which will slowly drift through Venus' atmosphere to make in situ measurements. The main part of the spacecraft will continue on to an encounter with Halley's comet in 1986, and will be the first probe to arrive there (others will be launched by the European Space Agency and Japan). The United States has agreed to track the balloons in Venus' atmosphere for the French, and the Soviet spacecraft as it reaches Halley's comet, to provide data to ESA with which to target its Giotto spacecraft.

The D launch vehicle was also used for the launchings of Mars 2 through 7. Mars 3 was the first to make a survivable landing with television, but signals ceased before the first complete picture was received on Earth. Mars 4 and 5 were intended as orbiters working with Mars 6 and 7 landers. Of these four only Mars 5 attained an orbit and Mars 6 a landing. Mars 6 returned direct readings within the atmosphere but signals ceased at the surface.

Six other Venus related flights were stranded in Earth orbit over the years, in addition to those already mentioned. One other Mars flight ended in Earth orbit in addition to those mentioned earlier. There have also been

press reports of additional Mars flight attempts which did not even reach Earth orbit, which reports are consistent with the failure of flights to appear to match the Russians' own predictions of their plans.

Had the heavy Mars vehicles of the U.S.S.R. been successful, many of the firsts of the Viking programs would have been Soviet prizes. Soviet orbiters in general put greater emphasis on a wide range of synoptic data readings, with color pictures less prominent than in the U.S. operations. The D class Soviet launch vehicle has demonstrated an ability to carry payloads up to 4,650 kilograms to Mars and 5,033 kilograms to Venus. The Venus landers weigh 1,560 kilograms each. These weights compare with U.S. Vikings at 3,400 kilograms and Viking landers at 1,090 kilograms each.

TABLE 4. Summary of Lunar Distance Flight Attempts

Launch date	Spacecraft name	Nationality	Weight (kg)	Cumulative national weight	Mission	Results
1958						
Aug. 17	Pioneer 0	US	38	38	Orbit Moon	Fail--exploded 16 km up.
Oct. 11	Pioneer 1	US	38	76	Orbit Moon	Fail--climbed 113,830 km, fell back over South Pacific.
Nov. 8	Pioneer 2	US	39	115	Orbit Moon	Fail--climbed 1,550 km, fell near Africa.
Dec. 6	Pioneer 3	US	6	121	Fly by Moon	Fail--climbed 102,320 km, fell back over Africa.
1959						
Jan. 2	Luna 1	USSR	361	361	Strike Moon	Partial--missed Moon by 5-6,000 km, entered solar orbit.
Mar. 3	Pioneer 4	US	6	127	Fly by Moon	Success--passed Moon at 60,050 km, entering solar orbit.
Sept. 12	Luna 2	USSR	390	751	Strike Moon	Success--struck 435 km from visible center.
Sept. 24	Pioneer P-1	US	170	297	Orbit Moon	Fail--exploded in static test before launch.
Oct. 4	Luna 3	USSR	435	1,186	Photo far side	Succeed--returned pictures of 70 percent of far side of Moon.
Nov. 26	Pioneer P-3	US	169	466	Orbit Moon	Fail--shroud tore away in launch, payload impacted near Africa.
1960						
Sept. 25	Pioneer P-30	US	176	642	Orbit Moon	Fail--impacted in Africa.
Dec. 15	Pioneer P-31	US	176	818	Orbit Moon	Fail--climbed 13 km and exploded.
1961						
Aug. 23	Ranger 1	US	306	1,124	Vehicle test	Fail--intended to climb to 1,102,850 km, but stayed in low Earth orbit.
Nov. 18	Ranger 2	US	306	1,430	Vehicle test	Fail--intended to climb to 1,102,850 km, but stayed in low Earth orbit.
1962						
Jan. 26	Ranger 3	US	330	1,760	TV, hard land	Partial--missed Moon by 36,808 km, no TV pictures or landed instruments.

TABLE 4. Summary of Lunar Distance Flight Attempts--continued

Launch date	Spacecraft	Nationality	Weight (kg)	Cumulative national weight	Mission	Results
Apr. 23	Ranger 4	US	331	2,091	TV, hard land	Partial--timer failed, fell on far side of Moon, no pictures.
Oct. 18	Ranger 5	US	342	2,433	TV, hard land	Partial--power failure, so missed Moon by 725 km, entered solar orbit.
1963						
Jan. 30	Unannnounced	USSR	1,400?	2,586	Moon soft land	Failed--Earth orbit only.
Apr. 2	Luna 4	USSR	1,422	4,008	Moon soft land	Partial--missed Moon by 8,500 km, barycentric or solar orbit.
1964						
Jan. 30	Ranger 6	US	365	2,798	TV before strike	Partial--on target, but no pictures taken.
Jul. 28	Ranger 7	US	366	3,164	TV before strike	Success--returned 4,308 pictures of Moon to impact.
Dec. 11	Centaur 2	US	952	4,116	Vehicle test	Fail--did not restart and soon fell in Australia.
1965						
Feb. 17	Ranger 8	US	367	4,483	TV before strike	Success--returned 7,137 pictures of Moon to impact.
Mar. 2	Centaur AC 5	US	635	5,118	Vehicle test	Fail--exploded at pad.
Mar. 12	Kosmos 60	USSR	1,470	5,478	Moon soft land	Fail--Earth orbit only.
Mar. 21	Ranger 9	US	366	4,484	TV before strike	Success--returned 5,814 pictures of Moon to impact.
May 9	Luna 5	USSR	1,476	6,954	Moon soft land	Partial--missed Moon by 160,000 km, entered solar or barycentric orbit.

TABLE 4. Summary of Lunar Distance Flight Attempts--continued

Launch date	Spacecraft name	Nationality	Weight (kg)	Cumulative national weight	Mission	Results
June 8	Luna 6	USSR	1,442	8,396	Moon soft land	Partial--missed Moon by 160,000 km, entered solar or barycentric orbit.
Jul. 18	Zond 3	US	890?	9,286	Photo far side	Success--returned 25 pictures, entered solar orbit.
Aug. 11	Centaur 3	US	952	6,436	Vehicle test	Success--reached 820,824 km out with Surveyor dynamic model, in barycentric orbit.
Oct. 4	Luna 7	USSR	1,506	10,792	Moon soft land	Partial--retrofired early, fell on Moon.
Dec. 3	Luna 8	USSR	1,552	12,344	Moon soft land	Partial--retrofired late, fell on Moon.
1966						
Jan. 31	Luna 9	USSR	1,583	13,927	Moon soft land	Success--returned 27 pictures from lunar surface.
Feb. 26	Apollo-Saturn 201	US	15,331	27,767	Vehicle test	Success--flew suborbitally to land in the Pacific.
Mar. 1	Kosmos 111	USSR	1,600?	15,527	Moon orbit	Fail--Earth orbit only.
Mar. 31	Luna 10	USSR	1,600	17,127	Moon orbit	Success--returned physical measurements from lunar orbit.
Apr. 8	Centaur 4	US	771	28,538	Vehicle test	Fail--low Earth orbit only.
May 30	Surveyor 1	US	995	29,533	Moon soft land	Success--returned 11,237 pictures from lunar surface.
Jul. 1	Explorer 33	US	93	29,626	Moon orbit	Partial--failed to approach Moon in barycentric orbit.
Jul. 5	Apollo-Saturn 203	US	26,535	56,161	Vehicle test	Success--simulated in Earth orbit a Saturn V flight.

TABLE 4. Summary of Lunar Distance Flight Attempts--continued

Launch date	Spacecraft name	Nationality	Weight (kg)	Cumulative national weight	Mission	Results
Aug. 10	Lunar Orbiter 1	US	387	56,548	Moon orbit	Success--returned 414 pictures of potential landing sites on Moon.
Aug. 24	Luna 11	USSR	1,604?	18,767	Moon orbit	Success--but failed to return pictures from lunar orbit.
Aug. 25	Apollo-Saturn 202	US	20,275	76,823	Vehicle test	Success--simulated reentry in sub-orbital flight.
Sep. 20	Surveyor 2	US	1,000	77,823	Moon soft land	Partial--stabilization failed, struck Moon.
Oct. 22	Luna 12	USSR	1,625?	20,392	Vehicle test	Success--returned pictures of Moon.
Oct. 26	Centaur 2	US	726	78,549	Vehicle test	Success--mass model of Surveyor carried to 465,032 km.
Nov. 6	Lunar Orbiter 2	US	390	78,939	Moon orbit	Success--returned 422 pictures of Apollo sites, far side.
Dec. 21	Luna 13	USSR	1,595?	21,987	Moon soft land	Success--returned pictures and soil density measures.
1967						
Jan. 27	Apollo-Saturn 204	US	20,412	99,351	Capsule test	Fail--burned on pad in exercise.
Feb. 5	Lunar Orbiter 3	US	385	99,736	Moon orbit	Success--returned 307 pictures of Apollo sites.
Apr. 17	Surveyor 3	US	1,035	100,771	Moon soft land	Success--returned 6,315 pictures, dug soil with shovel.
May 4	Lunar Orbiter 4	US	390	101,161	Moon orbit	Success--returned 326 pictures of large areas of the Moon.

TABLE 4. Summary of Lunar Distance Flight Attempts--continued

Launch date	Spacecraft name	Nationality	Weight (kg)	Cumulative national weight	Mission	Results
Jul. 14	Surveyor 4	US	1,039	102,200	Moon soft land	Partial--signals ceased at touch-down on Moon.
Jul. 19	Explorer 35	US	104	102,304	Moon orbit	Success--returned data from lunar orbit.
Aug. 1	Lunar Orbiter 5	US	390	102,694	Moon orbit	Success--returned 424 pictures including much of far side.
Sep. 8	Surveyor 5	US	1,005	103,699	Moon soft land	Success--returned 18,006 pictures, chemical analysis of soil.
Nov. 7	Surveyor 6	US	1,008	104,707	Moon soft land	Success--returned 30,065 pictures, chemical and mechanical soil study.
Nov. 9	Apollo 4	US	42,506	147,213	Vehicle test	Success--simulated full lunar return reentry in Earth orbit.
1968						
Jan. 7	Surveyor 7	US	1,040	148,253	Moon soft land	Success--returned 21,274 pictures, chemical analysis of soil from trench it dug.
Jan. 22	Apollo 5	US	14,379	162,632	Vehicle test	Success--tested lunar module in Earth orbit.
Mar. 2	Zond 4	USSR	5,800?	27,787	Vehicle test	Partial--flew to lunar distance but recovery in doubt.
Apr. 4	Apollo 6	US	42,577	205,209	Vehicle test	Partial--did not go to lunar distance but recovered payload.
Apr. 7	Luna 14	USSR	1,615?	29,402	Moon orbit	Success--returned data on lunar mass distribution.

TABLE 4. Summary of Lunar Distance Flight Attempts--continued

Launch date	Spacecraft name	Nationality	Weight (kg)	Cumulative national weight	Mission	Results
Sep. 14	Zond 5	USSR	5,800?	35,202	Circumlunar	Success--ballistic reentry with biological subjects and pictures.
Oct. 11	Apollo 7	US	20,577	225,786	Manned test	Success--flew in Earth orbit.
Nov. 10	Zond 6	USSR	5,800?	41,002	Circumlunar	Success--lifting reentry with biological specimens and pictures.
Dec. 21	Apollo 8	US	43,654	269,440	Moon orbit	Success--men in lunar orbit and recovered.
1969 Mar. 3	Apollo 9	US	47,167	316,607	Manned test	Success--tested lunar module rendezvous, crew recovered.
May 18	Apollo 10	US	48,638	365,245	Moon orbit	Success--tested lunar module rendezvous, at Moon, crew recovered.
Jul. 13	Luna 15	USSR	5,800?	46,802	Moon soft land	Partial--lunar orbit success, but landing failed.
Jul. 16	Apollo 11	US	49,698	414,943	Moon soft land	Success--first manned landing on Moon and return.
Aug. 7	Zond 7	USSR	5,800?	52,602	Circumlunar	Success--lifting reentry of photographs.
Sep. 23	Kosmos 300	USSR	5,800?	58,402	Moon soft land	Fail--Earth orbit only.
Oct. 22	Kosmos 305	USSR	5,800?	64,202	Moon soft land	Fail--Earth orbit only.
Nov. 14	Apollo 12	US	49,804	464,747	Moon soft land	Success--manned lunar landing and return with part of Surveyor 3.
1970 Apr. 11	Apollo 13	US	49,990	514,737	Moon soft land	Partial--explosion in service module limited flight to circumlunar; crew saved.

TABLE 4. Summary of Lunar Distance Flight Attempts--continued

Launch date	Spacecraft name	Nationality	Weight (kg)	Cumulative national weight	Mission	Results
Sep. 12	Luna 16	USSR	5,800?	70,002	Moon soft land	Success--made automated sample collection returned it to Earth.
Oct. 20	Zond 8	USSR	5,800?	75,802	Circumlunar	Success--ballistic reentry with photographs.
Nov. 10	Luna 17	USSR	5,800?	81,602	Moon soft land	Success--landed automated roving vehicle for long term exploration.
1971						
Jan. 31	Apollo 14	US	46,346	561,083	Moon soft land	Success--manned lunar landing and return.
July 26	Apollo 15	US	52,759	613,842	Moon soft land	Success--manned lunar landing, roving vehicle, safe return.
Sep. 2	Luna 18	USSR	5,800?	87,402	Moon soft land	Partial--lunar orbit success, but crashed on landing.
Sep. 28	Luna 19	USSR	5,800?	93,202	Moon orbit	Success--returned photographs and other data.
1972						
Feb. 14	Luna 20	USSR	5,800?	99,002	Moon soft land	Success--made automated sample collection, returned it to Earth.
Apr. 16	Apollo 16	US	48,606	662,448	Moon soft land	Success--manned lunar landing roving vehicle, safe return.
Dec. 7	Apollo 17	US	46,825	709,273	Moon soft land	Success--manned lunar landing, roving vehicle, safe return.
1973						
Jan. 8	Luna 21	USSR	5,800?	104, 802	Moon soft land	Success--landed automated roving vehicle for long term exploration.

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TABLE 4. Summary of Lunar Distance Flight Attempts--continued

Launch date	Spacecraft name	Nationality	Weight (kg)	Cumulative national weight	Mission	Results
Jun. 10	Explorer 49	US	328	709,601	Moon orbit	Success--radio astronomy from far side of Moon.
1974						
May 29	Luna 22	USSR	5,800?	110,602	Moon orbit	Success--returned pictures and data.
Oct. 28	Luna 23	USSR	5,800?	116,402	Moon soft land	Partial--landed safely, but drill damaged so no sample returned to Earth.
1976						
Aug. 9	Luna 24	USSR	5,800?	122,202	Moon soft land	Success--made automated sample collection, returned to Earth.

NOTES

1. The table includes all known attempts to send payloads to the Moon or to distances from Earth equal to the distance of the Moon from Earth, together with test flights in Earth orbit of lunar-associated hardware. It cannot include Soviet flight failures which did not reach Earth orbit because these are not in the public domain. Hence, the cumulative weight of Soviet payloads almost certainly understates reality.

2. Weights listed are in kilograms, with a second column showing a running total of kilograms for all flights to date of the same national origin.

3. In a very few instances, the mission has been assigned by inference, in terms of the context of the time in which it took place.

4. The test of success or failure is somewhat arbitrary. Any flight staying in relatively low Earth orbit as well as not achieving Earth orbit is counted as a failure. Flights which at least approached the Moon, although not achieving the estimated goal received the rating of partial success.

5. The Soviet label Luna was applied after the fact to the first flights which at the time were simply called Cosmic Rockets, with the third one called an Automatic Interplanetary Station (AIS 1). Luna 1 was also called Mechta (Dream).

SOURCES: Soviet data are from Soviet TASS bulletins for the most part, supplemented by inferential judgments that some Earth orbital flights were almost certainly lunar attempts which failed, based upon the timing of the launch, the nature of the debris in Earth orbit, the launch vehicle used, and the orbital path chosen. U.S. data are based mostly on NASA press releases, although the first lunar attempt was sponsored and reported on by the Advanced Research Projects Agency (ARPA) of the Department of Defense before the creation of NASA. Estimated weights of Luna 11, 12, 13 and 14 by D.R. Woods. Weights of Luna 15 on, and Zond 4-8 were estimated by the Royal Aircraft Establishment.

TABLE 5. Summary of Planetary Distance Flight Attempts

Launch date	Spacecraft name	Nationality	Weight (kg)	Cumulative national weight	Mission	Results
1960						
Mar. 11	Pioneer 5	US	43	43	Interplanetary toward Sun	Success--returned data from 36.2 million kilometers.
Oct. 10	Unacknowledged	USSR	640?	640?	Mars	Fail--did not reach Earth orbit.
Oct. 14	Unacknowledged	USSR	640?	1,280	Mars	Fail--did not reach Earth orbit.
1961						
Feb. 4	Tyazheliy Sputnik 4	USSR	640?	1,920	Venus	Fail--Earth orbit only.
Feb. 14	Venera 1	USSR	644	2,564	Venus	Partial--communications failed; passed Venus at 100,000 km.
1962						
Jul. 22	Mariner 1	US	202	245	Venus flyby	Fail--destroyed at 160 km altitude.
Aug. 25	Unacknowledged	USSR	890?	3,454	Venus	Fail--Earth orbit only.
Aug. 27	Mariner 2	US	203	408	Venus flyby	Success--passed Venus at 34,853 km.
Sep. 1	Unacknowledged	USSR	890?	4,344	Venus	Fail--Earth orbit only.
Sep. 12	Unacknowledged	USSR	890?	5,234	Venus	Fail--Earth orbit only.
Oct. 24	Unacknowledged	USSR	890?	6,124	Mars	Fail--Earth orbit only.
Nov. 1	Mars 1	USSR	894	7,018	Mars	Partial--communications failed, passed Mars at 191,000 km.
Nov. 4	Unacknowledged	USSR	890?	7,908	Mars	Fail--Earth orbit only.
Nov. 11	Kosmos 21	USSR	890?	8,798	Venus test	Fail--Earth orbit only.
1964						
Mar. 27	Kosmos 27	USSR	890?	9,688	Venus	Fail--Earth orbit only.
Apr. 2	Zond 1	USSR	890?	10,578	Venus	Partial--communications failed, passed Venus at 100,000 km.
Nov. 5	Mariner 3	US	261	669	Mars flyby	Fail--shroud did not separate, thrown into wrong orbit.
Nov. 28	Mariner 4	US	261	930	Mars flyby	Success--returned 22 pictures.
Nov. 30	Zond 2	USSR	890?	11,468	Mars	Partial--communications failed, passed Mars at 1,500 km.

TABLE 5. Summary of Planetary Distance Flight Attempts--continued

Launch date	Spacecraft name	Nationality	Weight (kg)	Cumulative national weight	Mission	Results
1965						
Jul. 18	Zond 3	USSR	890?	12,358	Mars test	Success--returned 25 pictures of Moon far side, retransmitted from increasing distances.
Nov. 12	Venera 2	USSR	963	13,321	Venus flyby	Partial--communications failed, passed Venus at 24,000 km.
Nov. 16	Venera 3	USSR	960	14,281	Venus land	Partial--communications failed, struck Venus 450 km from visible center.
Nov. 23	Kosmos 96	USSR	960?	15,241	Venus	Fail--Earth orbit only.
Dec. 16	Pioneer 6	US	61	991	Interplanetary toward Sun	Success--returned data.
1966						
Aug. 17	Pioneer 7	US	61	1,052	Interplanetary away from Sun	Success--returned data.
1967						
Jun. 12	Venera 4	USSR	1,106	16,347	Venus land	Success--returned direct readings of atmosphere to 25 km altitude.
Jun. 14	Mariner 5	US	245	1,297	Venus flyby	Success-returned data, passed Venus at 4,094 km.
Jun. 17	Kosmos 167	USSR	1,100?	17,447	Venus	Fail--Earth orbit only.
Dec. 13	Pioneer 8	US	66	1,363	Interplanetary away from Sun	Success--returned data.
1968						
Nov. 8	Pioneer 9	US	67	1,430	Interplanetary toward Sun	Success--returned data.
1969						
Jan. 5	Venera 5	USSR	1,130	18,577	Venus land	Success--returned direct readings of atmosphere to near surface.

TABLE 5. Summary of Planetary Distance Flight Attempts--continued

Launch date	Spacecraft name	Nationality	Weight (kg)	Cumulative national weight	Mission	Results
Jan. 10	Venera 6	USSR	1,130	19,707	Venus land	Success--returned direct readings of atmosphere to near surface.
Feb. 25	Mariner 6	US	380	1,810	Mars flyby	Success--returned 24 pictures and other data.
Mar. 27	Mariner 7	US	380	2,190	Mars flyby	Success--returned 31 pictures and other data.
Aug. 27	Pioneer E	US	66	2,256	Interplanetary at Earth orbit	Fail--destroyed by range safety.
1970						
Aug. 17	Venera 7	USSR	1,180	20,887	Venus soft land	Success--sent back data from atmosphere and surface of Venus.
Aug. 22	Kosmos [illegible]	US	1,180	22,067	Venus soft land	Fail--Earth orbit only.
1971						
May 8	Mariner 8	US	1,029	3,285	Mars orbit	Fail--fell in Atlantic Ocean.
May 10	Kosmos 419	USSR	4,650?	26,717	Mars soft land	Fail--Earth orbit only.
May 19	Mars 2	USSR	4,650	31,367	Mars soft land	Partial--returned data from orbiter, but lander destroyed.
May 28	Mars 3	USSR	4,650	36,017	Mars soft land	Success--returned orbital data and survived landing.
May 30	Mariner 9	US	1,030	4,315	Mars orbit	Success--returned 6,786 pictures of Mars.
1972						
Mar. 3	Pioneer 10	US	258	4,573	Jupiter flyby	Success--returned pictures and other data.
Mar. 27	Venera 8	USSR	1,180?	37,197	Venus soft land	Success--atmospheric data and soil analysis returned.
Mar. 31	Kosmos 482	USSR	1,180?	38,377	Venus soft land	Fail--Earth orbit only.

TABLE 5. Summary of Planetary Distance Flight Attempts--continued

Launch date	Spacecraft name	Nationality	Weight (kg)	Cumulative national weight	Mission	Results
1973						
Apr. 6	Pioneer 11	US	259	4,832	Jupiter, Saturn flyby	Success--returned Jupiter and Saturn pictures and data.
Jul. 21	Mars 4	USSR	4,150?	42,527	Mars orbit	Partial--returned data and in flyby, did not enter orbit.
Jul. 25	Mars 5	USSR	4,150?	46,677	Mars orbit	Success--returned data and pictures.
Aug. 5	Mars 6	USSR	4,150?	50,827	Mars soft land	Partial--returned data from flyby, but lander signals ceased.
Aug. 9	Mars 7	USSR	4,150?	54,977	Mars soft land	Partial--returned data from flyby, but lander missed by 1,300 km.
Nov. 3	Mariner 10	US	504	5,336	Venus, Mercury flyby	Success--returned pictures from Venus and three times pictures from Mercury.
1974						
Dec. 10	Helios 1	German Fed. Rep./US	370	5,706	Sun approach	Success--returned data.
1975						
Jun. 8	Venera 9	USSR	4,936	59,913	Venus soft landing	Success--returned pictures and other data.
Jun. 14	Venera 10	USSR	5,033	64,946	Venus soft landing	Success--returned pictures and other data.
Aug. 20	Viking 1	US	3,400	9,106	Mars soft landing	Success--returned pictures and other data.
Sep. 9	Viking 2	US	3,400	12,506	Mars soft landing	Success--returned pictures and other data.
1976						
Jan. 15	Helios 2	German Fed. Rep./US	376	12,882	Sun approach	Success--returned data.

TABLE 5. Summary of Planetary Distance Flight Attempts--continued

Launch date	Spacecraft name	Nationality	Weight (kg)	Cumulative national weight	Mission	Results
1977						
Aug. 20	Voyager 2	US	700	13,582	Jupiter, Saturn, Uranus flybys	Success--returned pictures and data from Jupiter.
Sep. 5	Voyager 1	US	700	14,282	Jupiter, Saturn flybys	Success--returned pictures and data from Jupiter and Saturn.
1978						
May 20	Pioneer Venus 1	US	549	14,831	Venus orbit	Success--returned data and pictures.
Aug. 8	Pioneer Venus 2	US	904	15,735	Venus probe	Success--five vehicles returned direct data from atmosphere.
Sep. 9	Venera 11	USSR	3,940?	68,886	Venus soft land	Success--returned data from surface.
Sep. 14	Venera 12	USSR	3,940?	72,826	Venus soft land	Success--returned data from surface.
1981						
Oct. 20	Venera 13	USSR	3,940?	76,766	Venus soft land	Success--landed on March 1, 1982.
Nov. 4	Venera 14	USSR	3,940?	80,706	Venus soft land	Success--landed on March 5, 1982.
1983						
June 2	Venera 15	USSR	3,940?	84,646	Venus orbit, radar	Success--achieved orbit Oct. 10, 1983.
June 7	Venera 16	USSR	3,940?	88,586	Venus orbit, radar	Success--achieved orbit Oct. 14, 1983.

NOTES

1. The table includes all known attempts to send payloads to the planets or into solar orbit, not including those intended to go to the Moon which only incidentally may have escaped barycentric orbit to enter heliocentric orbit. It cannot include additional Soviet flight failures which did not reach Earth orbit, when not in the public domain. The only year in which there had been persistent reports of Soviet intentions to launch planetary flights for which there is no public record of failures is 1969. This could mean that Mars flights using the D-1-e vehicle began in that year, but failed to reach Earth orbit.

2. Weights listed are in kilograms, with a second column showing a running total of kilograms for all flights to data of the same national origin.

3. In a few instances, the mission has been assigned by inference, in terms of the context of the time in which it took place. Some of the Soviet flights to the planets may have been orbiters or landers, but no attempt has been made to guess the mission other than that of the planet name.

4. The test of success or failure is somewhat arbitrary. Any flight staying in relatively low Earth orbit as well as those not achieving Earth orbit are counted as failures. Flights at least approaching interplanetary distances although not achieving their estimated goal received the rating of partial success.

SOURCES: Soviet data are from Soviet TASS bulletins for the most part, supplemented by inferential judgments that some Earth orbital flights were almost certainly planetary attempts which failed, based on the timing of the launch, the nature of the debris in Earth orbit, the launch vehicle used, and the orbital path chosen. U.S. data are based mostly on NASA press releases. Weight estimates for the more recent Mars and Venus flights by the Russians have been varied from the weight of Mars 2 and 3 at the suggestion of D.R. Woods and C.P. Vick, to reflect approximate energy requirement effects on payloads.

CHAPTER FIVE: MILITARY SPACE ACTIVITIES

A. MILITARY VERSUS CIVIL SPACE PURPOSES

For the most part there seems to be little difference between the Soviet and U.S. space programs as to general purpose and direction (with two major exceptions to be noted later). Both are broadly based, with elements of scientific exploration, technology development, national image building, practical applications, and military support services. Cumulatively, about 55 percent of U.S. flights have been conducted for the Department of Defense, with 43 percent for strictly military purposes, while approximately 66 percent of successful Soviet flights have been for strictly military purposes. In fiscal year 1983, approximately 53 percent of U.S. space funding was for DOD space activities. A corresponding breakdown for the Soviet total program is harder to establish because of their secrecy of budget data, and their claim that all flights are scientific. Yet a very considerable number of their flights and research give convincing indications of serving military purposes.

B. MANAGEMENT OF SPACE PROGRAMS

Under the terms of the National Aeronautics and Space Act of 1958, a major portion of the U.S. space program is run by a civilian organization, the National Aeronautics and Space Administration. Another major segment is operated by the Department of Defense using the Air Force as its executive

agent, with emphasis on supplying military support, or doing the R&D associated with military support. Lesser amounts of the program are scattered among other development or user agencies such as the Department of Energy (development), the Departments of Commerce, Transportation, Agriculture and Interior (users). The National Aeronautics and Space Council, a coordinating body which operated from 1958 to 1973, was abolished by President Nixon.

Much less is known about the Soviet pattern of organization. The Russians have held secret even the names of their top space officials with very few exceptions. Nor are the exact names of all their space organizations known. The Soviet Academy of Sciences plays a role in planning a part of the program. The Soviet Strategic Rocket Force conducts launches and apparently is responsible for supplying the launch vehicles. The interfaces are obscure, however, and if there are construction and testing ministries in between, little is known of them.

C. POTENTIAL THREAT OF MILITARY FLIGHTS

United States policy has been that its military flights are nonaggressive. Many of its military flights are hardly distinguishable from flights conducted for civilian application purposes. Thus a message sent by satellite, or a weather report from space observation, or navigational data to a ship, are technically neutral in character. Often these services are of a traditional nature, simply done more speedily or cheaply by space means. Whether such services are aggressive is in the mind of the user, and are not subject to scientific, absolute determination. In a philosophical sense, a businessman

or a Government civil department sending a message by satellite might be more "aggressive" than a military user sending data on personnel counts or number of wool socks in a warehouse somewhere.

Although the U.S. Government is reluctant to discuss the subject, careful observers of military space activities have a strong conviction that the most active development of military space flights lies in the area of Earth observation. President Johnson, speaking in Nashville, Tennessee on March 15, 1967, claimed in an "off-the-record" statement widely reported at the time that the dividends of military space operations to the United States were equal to ten times everything which had been spent on space. This implied savings in the defense budget over a ten year period on the order of $400 billion, because of more precise information about military and related activities all over the world. American analysts argue that sure information from space is one of the greatest safeguards against miscalculation by the major powers, and hence, in the absence of explicit international agreements for open skies and ground inspection, is a fair bargain in reducing the risks and costs stemming from erroneous impressions. President Carter on October 1, 1978, officially acknowledged the U.S. role in military photoreconnaissance from space.

There is no doubt that the Soviet Union has a large and regular program of military support flights, including use of satellites for photographic observation, early warning, electronic listening, weather reporting, communications relaying, and ship navigation. Although these space services undoubtedly enhance Soviet military capabilities, in net balance they probably are to the advantage of the United States if surer knowledge between these two big powers makes each more cautious and less prone to error in estimates.

D. SPACE WEAPONS

1. Soviet Fractional Orbital Bombardment System (FOBS)

Ever since the days of Sputnik 1, there has been public worry about nuclear bombs dropped from orbit. The potential threat is there, but it must be qualified by many practical considerations. A bomb in orbit must be called down by signal, and on a particular orbit would fall close only to a selected path defined by the orbit, so that hitting a planned target is possible only at certain hours or days, and in a sudden emergency might not be near a useful target. It also may be subject to malfunction and might fall on a city in the country that launched it (or an ally) as well as one in an enemy country. A bomb in fixed orbit can be precisely located, and hence intercepted by another space power.

Although no country has placed nuclear bombs in orbit to date, the Soviets tested a system from 1967-1971 called a Fractional Orbital Bombardment System (FOBS) which could be considered such a device if it ever became operational. This was not a technical violation of the 1967 Outer Space Treaty, which bans placing nuclear weapons in orbit, because there is no reason to assume they carried nuclear material on board the test flights, and the dummy warhead flew less than one full orbit. The pattern was to launch a satellite from the Soviet Union on a path avoiding the United States and call down the test warhead just before the end of the first orbit onto Soviet territory, while some minor debris and expended rocket casing stayed in orbit for a few more hours before decaying.

Opinion is divided in the West as to whether the Russians ceased testing the FOBS system in 1971 because they determined it was not worthwhile, or because it is operational. If the system still exists, the Soviets might consider it advantageous from the point of view of complicating U.S. defenses. Although scientifically speaking the warhead is in orbit, in effect it is like an extended range ICBM capable of flying the long way around the world to bypass the normal ballistic missile early warning system (BMEWS) radar fences which primarily point to the north. If flown by the usual shortest routes to the United States, it could do so with a depressed apogee compared with conventional ICBMs, so as to cut warning time to BMEWS because of the delayed detection brought by the curvature of the Earth hiding the presence of the low-flying warhead. Such flights in combat have disadvantages, however, including reduced accuracy on target if coming the long way around, and reduced payload by any route compared with the use of the same launch vehicle as an ICBM. The United States does not have a FOBS program because it does not regard it as necessary or desirable.

2. Early U.S. and Soviet Antisatellite Missiles

In 1962, Nikita Khruschev stated in an interiew with American newspaper editors that the Soviet Union had a missile that could "hit a fly in outer space." This was interpreted by some as an indication of an antisatellite capability, perhaps using the Galosh ballistic missiles emplaced around Moscow.

In response, the United States developed its own antisatellite system using missiles based on Johnston Island and Kwajalein Atoll in the Pacific.

The system was termed operational by President Johnson in a 1964 speech. The system would not have met all possible needs, but over the course of some days could have intercepted most satellites in sustained low orbit. These facilities are believed to have been shut down in 1975. The Soviet Galosh system may still be capable of intercepting hostile satellites to about the same degree as the United States could have from its mid-Pacific installations.

3. Existing Soviet Co-Orbital ASAT Device

Beginning in 1968, the Soviets began testing a co-orbital ASAT device; a total of 20 tests have been conducted so far. The interceptor is launched by a variant of the SS-9 booster and goes inco a close co-orbit with the target satellite. In operation, the interceptor would then maneuver close to the target and explode (using a chemical explosive), destroying the operational capability of the target with shrapnel. In the tests, no satellite has actually been destroyed. Instead, the interceptor either moves off and then explodes, or is commanded to reenter. Without knowing the test objectives in each case, it is difficult to assess from open sources how successful these tests have been, but it is generally concluded in the West that 50-70 percent of the tests have been successful.

Tests were conducted from 1968 to 1971, after which a four year hiatus occurred. Testing resumed in 1976, the year after the U.S. dismantled its missile ASAT system, and after the Chinese had orbited their first prototype reconnaissance satellite. Whether these factors led to the resumption in testing, or whether the Soviets introduced a system with new technology at that time, is unknown. The United States declared the Soviet system

operational in 1977 and decided to develop its own advanced ASAT (see next section). At the same time, President Carter called on the Soviets to negotiate a treaty to ban weapons from space, and during the course of those talks in 1978-1979, the Soviets once again ceased tests of their ASAT device. When the negotiations ended (following the Soviet invasion of Afghanistan in late 1979), the ASAT tests resumed, with one test in 1980, two in 1981, and one on 1982. No ASAT tests were conducted in 1983.

The Soviet system is limited by the altitudes and inclinations at which it can be used. U.S. communications and early warning satellites are currently outside the range of the Soviet ASAT, although future developments (such as using a more capable launch vehicle) could enhance its range.

4. U.S. F-15 ASAT Device

In 1977, following the Pentagon's assessment that the Soviet ASAT system was operational, President Carter authorized DOD to develop a U.S. ASAT device. Unlike the Soviet system, which is launched from the ground like a typical satellite, the U.S. ASAT device, called a Miniature Homing Vehicle (MHV), will be launched from a two-stage rocket attached to an F-15 aircraft. With this mobility, it can go to the satellite that is to be attacked, rather than waiting for the satellite to be in a correct orbital position to be intercepted from a ground launch site. The MHV would destroy its target by direct impact, and will not carry any explosive material. The U.S. ASAT system is still being developed, and is expected to be operational in 1987. During 1983, captive carry tests were conducted with the ASAT, in which a dummy MHV was carried to test the aerodynamics of

the system. An active test where an MHV would be fired against a point in space was expected to take place in 1983, but according to the trade press, was delayed until 1984.

The U.S. ASAT is limited in altitude, probably to about the same range as the Soviet ASAT, but can attack satellites at any inclination. Soviet communications and early warning satellites are in different orbits than their American counterparts, with a low point only 500 kilometers above the surface. These probably are within range of the U.S. ASAT, although the low point of the orbit is over the ocean, so the F-15 (which is not designed to be based on an aircraft carrier) might require in-flight refueling to reach the satellite.

E. OCEAN SURVEILLANCE

Another part of the Soviet maneuverable satellite program using the F launch vehicle has been identified by DOD and by a British analyst as probably used for ocean surveillance by active radar able to penetrate clouds and darkness. These are often referred to as RORSATs (radar ocean reconnaissance satellites). When the main mission ends some weeks after launch, the craft separates into several parts with one segment fired into a higher orbit with a 600 year life, because of a nuclear power source contained in it. Confirmation of the power system came when malfunctioning Kosmos 954 fell in Canada on January 24, 1978 and spread radioactivity in a swath across the Northwest Territories. After the accident, no similar flights were made until April 1980. In 1981, three RORSATs were launched, and there were four in 1982. One of these (Kosmos 1402) failed to separate correctly and it reentered in two pieces on January 23 and February 7, 1983. During the incident, the

Soviets revealed a new safety procedure that had been incorporated since 1978 which separates the reactor core from the rest of the satellite to ensure its complete burn up in the atmosphere. No pieces of Kosmos 1402 were recovered and there was no evidence of increased radioactivity in the areas where the pieces reentered.

A second category of ocean surveillance flights stays at a higher altitude and is not maneuvered upwards later. Speculation is that these are electronic ferrets (called EORSATs), and use electric propulsion rather than nuclear power.

F. MUTUAL NONINTERFERENCE

For the time being at least, it remains in the Soviet interest not to interfere actively with U.S. satellite flights just as it is U.S. policy not to interfere with theirs. The SALT I agreement included a provision for noninterference with "national technical means" for policing compliance. The first visible new threat to such reciprocity was the report of late 1975 that the Russians had begun probing U.S. military satellites with powerful laser beams. If true, this could lead to very destabilizing relations in space. A follow-up Department of Defense analysis was that Soviet gas pipeline fires accounted for the phenomena of temporary saturation of these space-borne sensors. If correct, that may be reassuring, although technologically the laser threat may be possible.

In February 1983, reports in the Western press suggested that at least one U.S. reconnaissance satellite mysteriously ceased functioning over the Soviet Union, implying some sort of hostile act. No confirmation or denial of this alleged incident has been made yet by U.S. Government officials.

G. CONCERNS ABOUT THE MILITARIZATION OF SPACE AND "STAR WARS"

In the early 1980's, concern began to grow about the apparent "militarization" of space, that is, the increasing use of space for military purposes, particularly weapons. As noted above, the 1978-79 negotiations initiated by President Carter and aimed at developing a treaty to ban weapons from space were unsuccessful. In 1981, the Soviets introduced a draft treaty at the United Nations, but a close reading showed that it would ban only the stationing of weapons in space, and since neither the existing Soviet ASAT nor the U.S. system in development is stationed in space, the treaty would have had little impact. No negotiations were held on this text.

In March 1983, President Reagan made a nationally televised address in which he called for studies into technologies that could defend the United States and its allies against ballistic missile attacks. His advisers stated that these systems could be based on the ground, or in space, leading the media to dub this the "Star Wars" speech. Concern about the militarization of space intensified following the President's address, even though no decision has been made to deploy weapons in space. The initiation of testing of the U.S. ASAT also heightened concerns about war in space.

In August 1983, the Soviets introduced a revised draft treaty at the U.N. which would ban the use of force in space, a much broader scope than the earlier draft, [illegible]y prohibiting both ASAT and ballistic missile defense activities in or[illegible]iet President Andropov also committed his country "not to be the f[illegible] ASAT weapons in space, but avoided any admission that they have [illegible] a system since 1968.

The Reagan Administration has declined to negotiate with the Soviets about a space weapons ban because no foolproof methods for verifying compliance with such a treaty have been identified. The Arms Control and Disarmament Agency is currently assessing the potential verification problems and methods of resolving them.

From the Soviet perspective, the advent of the U.S. space shuttle has contributed to their concerns about U.S. military intentions in space. The 1981 Soviet draft treaty would have prohibited the deployment of weapons, inter alia, on "piloted space vessels of multiple use." The 1983 revision would ban the use of manned spacecraft for military purposes.

H. SUMMARY TABLE OF MILITARY VS. CIVILIAN SPACE FLIGHTS

The table which follows attempts to divide as meaningfully as possible, though still tentatively, the space flights of the two nations as to whether they are civilian or military in character. These distinctions are very difficult to draw in many cases (especially communications and navigation) and therefore are arbitrary to a certain extent.

TABLE 6

Approximate Comparison of U.S. and Soviet Successful Space Launches --
Primarily Civil Versus Presumptively Military*

	Primarily or Ostensibly Civil				Presumptively Specialized Military	
Year	NASA	DOD	U.S. Total	USSR	DOD	USSR
1957	0	0	0	2	0	0
1958	0	5	5	1	0	0
1959	5	0	5	3	5	0
1960	5	1	6	3	10	0
1961	10	0	10	6	19	0
1962	18	3	21	15	31	5
1963	10	2	12	10	26	7
1964	22	3	25	15	32	15
1965	24	11	35	23	28	25
1966	30	11	41	17	32	27
1967	26	8	33	20	24	46
1968	19	6	25	25	20	49
1969	21	3	24	19	16	51
1970	12	2	14	26	15	55
1971	15	7	21	23	10	60
1972	17	3	20	21	11	53
1973	12	3	15	28	8	58
1974	16	2	16	29	6	52
1975	18	3	21	29	7	60
1976	13	6	19	25	7	74
1977	13	2	15	29	9	69
1978	19	5	24	28	8	60
1979	7	5	12	27	4	60
1980	5	3	8	25	5	64
1981	11	2	13	39	5	59
1982	12	0	12	33	6	68
1983	15	0	15	40	7	58
TOTAL	375	96	467	561	351	1,075

* To a degree, classification has been arbitrary.

CHAPTER SIX: SUPPORTING RESOURCES FOR SPACE FLIGHT

The ability of the two leading space powers to perform depends in the short run on the availability of existing resources to support such flights. These consist of finances, manpower, laboratories, factories, launch sites, tracking facilities, and launch vehicles. This section examines these categories to the extent data are available.

A. SPACE EXPENDITURES OF THE U.S. AND U.S.S.R.

The United States, by September 1983, had spent about $166 billion total since the beginning of the space program on space work in the several agencies of Government involved. In fiscal year 1984, these expenditures should be about $18 billion ($7.2 billion for NASA, $9.9 billion for DOD, the rest for other agencies). At its peak, the United States was spending close to one percent of its gross national product on space, and today it is spending about one-third of one percent. (These are current dollars unadjusted for inflation.)

The Soviet Union does not publish space budget data. Because the Soviets fly a greater weight of hardware, one could assume that their program is at least of the same magnitude as that of the United States at its former peak, and may be larger. In 1982, a U.S. Government estimate was made suggesting that the Soviets spent $18 billion in 1982 (or about 50 percent more than the $13 billion spent in the United States) on its space program.

International comparisons of this nature are notoriously difficult to make, and one should avoid the temptation to convert such crude estimates into ruble or dollar equivalents.

B. MANPOWER

In the United States, the National Aeronautics and Space Administration (NASA) program alone at its peak employed about 400,000 people (with 7 percent of these on the NASA payroll), but now has dropped to about 134,000. There were probably about 600,000 people at the peak employed in total U.S. space work. This figure does not include the indirect beneficiaries of the space program from the multiplier effects of these expenditures, nor does this figure emphasize the dependence of some regions upon space expenditures.

The Soviet Union does not disclose how many people are employed in its space work. The productivity of this work force in comparison with that of the United States is not known, either. One would like to think our productivity is higher, but some Soviet approaches to space development may be simpler than ours, which incorporate very extensive testing and duplicative facilities in our industry. The Soviet work force may be close to 600,000 people because their effort today seems to be at least equal to our 1966 peak.

C. SPACE LABORATORIES AND FACTORIES

The United States has several major NASA development centers, and other facilities operated by the Air Force and the Department of Energy. The private aerospace industry has a widespread industrial base capable of building and testing our hardware. However, the reduction of manpower at work in the space industry by more than one half has dispersed many of the trained teams needed to man these facilities, and any resumption of full scale efforts to utilize the physical plant could not come immediately.

The Soviet Union does not allow visits to many of its development facilities and no real measure of its total capacity is available in the public domain. Western observers are aware of the existence of many technical and scientific institutes, and have heard of a special space city in Kazakhstan (Leninsk?) where it is believed major assembly work is done. There is no reason to believe the total Soviet aerospace industry is as fully equipped as that of the United States, because of their tendency to do more testing in flight compared with the United States. On the other hand, missiles of somewhat similar capabilities, but with different design philosophies, appearing in Moscow parades suggest the existence of more than one design and development team for space work just as in Soviet aviation. Early in 1979, reports circulated that there are five design bureaus for missiles and launch vehicles alone.

D. LAUNCH SITES

The United States has its major launch site for manned, lunar, planetary, and communications satellites at Cape Canaveral, Florida. It has a second important site for polar orbit military support flights and most weather, Earth resources, and navigation launchings on the California coast at Vandenberg Air Force Base. A third minor site for small payloads is at Wallops Island, Virginia. Short-range vertical testing also is done at White Sands, New Mexico.

The Soviet Union has developed launch sites amazingly like the United States pattern. Their major site for manned, lunar, planetary, and some communications satellites, plus other developmental work, is near Tyuratam and

Leninsk in Kazakhstan. They call it the Baykonur Cosmodrome, but it is about 370 kilometers from the town of Baykonur. A second, largely military operational site, but also used for navigation, communication, and weather satellites, is near Plesetsk in the arctic north of Moscow. The third site is more modest, near Kapustin Yar on the Volga, south of what used to be Stalingrad (now Volgograd). It launches vertical probes (like White Sands) and small orbital payloads (like Wallops Island).

Each country seems to be adequately equipped with launch pads and ground support. Of course, as new vehicle systems come along, these require additional specialized facilities. The Soviet Union does not permit routine visits to its launch sites, and General de Gaulle with his personal physician (in 1966) and President Pompidou (in 1970) were the only known Westerners to have visited Tyuratam until 1975, when a few Americans had a limited glimpse of this base. Eastern European, Swedish, and Indian scientists have been allowed to attend launches of their payloads at Kapustin Yar, Plesetsk, and Tyuratam (in the case of countries supplying cosmonauts).

Table 7 summarizes the number of launch successes and resulting payloads from all sites of the world through 1981.

TABLE 7. Summary of World-Wide Successful Space Launches by Site 1957-1983

Launch Site	Earth Orbit		Lunar or Escape		Cumulative Total
	1983	1957-1982	1983	1957-1982	
Plesetsk (U.S.S.R.)	62	869	0	0	931
Tyuratam (U.S.S.R.)	30	541	2	53	626
Vandenberg AFB (U.S.)	11	441	0	0	452
Cape Canaveral (U.S.)	11	275	0	58	344
Kapustin Yar (U.S.S.R.)	4	75	0	0	79
Wallops Island (U.S.)	0	18	0	0	18
Uchinoura (Japan)	1	12	0	0	13
Shuang Cheng-Zi (China)	1	10	0	0	11
Kourou (Guyana)	2	9	0	0	11
Tanegashima (Japan)	2	9	0	0	11
Indian Ocean Platform (Kenya)	0	8	0	0	8
Hammaguir (Algeria)	0	4	0	0	4
Sriharikota (India)	1	2	0	0	3
Woomera (Australia)	0	2	0	0	2
Total	125	2,275	2	111	2,513

E. TRACKING FACILITIES

As an outgrowth of the IGY period, the United States created a worldwide tracking system with the cooperation of many other countries. This has been upgraded to a much higher capacity to meet the needs of Apollo as well as other programs. For U.S. deep space work, it has large 34- or 64-meter diameter dish antennas in California, Australia, and Spain which supported the lunar portion of Apollo and support distant planetary flights. Even with all these facilities, its system has had to be supplemented with tracking ships and special electronic-systems aircraft working in conjunction with satellites used to relay data on a real-time basis. NASA's Tracking and Data Relay Satellite System (TDRSS) will perform most of these functions in the future. The first TDRS was launched in 1983; two more are scheduled for 1984.

The Soviet Union claims to have a nationwide tracking system, and the great spread of their country (about 2-1/2 times that of the United States) gives them a good systems start without leaving their own territory. There have been occasional press reports of Soviet efforts to put some tracking facilities into other countries such as in Africa or in Cuba. Their principal deep space tracking facility is in the Crimea and was visited over 20 years ago by Sir Bernard Lovell of the United Kingdom who headed the Jodrell Bank radio telescope facility. The military flight control center at the same Crimean location was visited by some American children under the auspices of the Young Pioneers in 1976.

Primarily, the Soviet Union accepts certain constraints to their space operations, and relies on ships to fill in gaps. Eleven ships have been named as assigned to the Soviet Academy of Sciences for space work, and often these are described as scattered around the world for space support purposes. Other tracking ships, not identified as under Academy control, have been pictured in the press and seem to be associated primarily with military missile tests, but could support space work as well. The most impressive tracking ship was the Kosmonavt Vladimir Komarov, used for lunar support work in the tropical waters of the Western Atlantic Ocean. Now it is outclassed by the larger Akademik Sergey Korolev, and much larger Kosmonavt Yuriy Gagarin. For support of manned flights, one ship typically anchors off Nova Scotia. Soviet Molniya satellites relay information between tracking ships and the U.S.S.R. The principle of launch constraints is to make flights only at times and places which will be in view of Soviet tracking stations at critical periods during the flight, and at other times to do without tracking, storing on tape in

the space craft some data for later replay. The Kosmonavt Vladislav Volkov, first of four new tracking ships, entered service in 1977, followed by the Kosmonavt Pavel Belyayev, Kosmonavt Georgiy Dobrovolskiy, and Kosmonavt Viktor Patseyev, retiring some of the earlier ships.

In 1982, the Soviets filed plans with the International Telecommunication Union for a satellite system which appears to be very similar to the U.S. TDRSS. When such a system might be launched is unknown.

F. LAUNCH VEHICLES

The United States has used launch vehicles scaled to lift payloads from as light as 9 kilograms up to the Saturn V which could carry over 136,000 kilograms to low Earth orbit. In its manned programs, the Mercury spaceship (weighing about 1,360 kilograms) was launched to orbit by Atlas. The Gemini (weighing about 3,630 kilograms) was launched by Titan II. The first manned Apollo flight was about 20,410 kilograms, and was put up by Saturn I B. The lunar version Apollos, launched by Saturn V, were about 52,600 kilograms in the vicinity of the Moon. (For any launch vehicle, the farther the orbit is from the Earth, the greater the velocity required to get there and the smaller the payload. This is why Saturn V carries much less to the Moon than to Earth orbit.)

In 1957 the Soviet Union started to use its original ICBM, with an orbital lift capacity of 1,360 kilograms. The same basic (A) vehicle is in use today with upper stages added to improve performance. These upper stages permitted the launch of about 450 kilograms to the Moon in the first Luna series, and about 1,500 kilograms in the second Luna series. The early Luna-type launch rocket also was able to put up Vostok manned craft of 4,700

kilograms. The weight of Soyuz is about 6,575 kilograms still using this same basic launch vehicle with improved staging. Their Proton (D) launch vehicle has been demonstrated to carry 20,000 kilograms to Earth orbit. Its circumlunar capacity should be on the order of 4,820 kilograms; and used to Mars, it carried 4,650 kilograms. The very large Soviet (G) vehicle confidently predicted by NASA officials over a decade ago has not yet been launched and may have been retired after major launch failures. Lesser Soviet launch vehicles (B, C, and F) account for other unmanned programs.

Table 4 summarizes world-wide use of basic vehicles for successful launches to Earth orbit and beyond, through 1981

TABLE 8. World-Wide Summary of Successful Launches by Basic First Stage, 1957-1983

Name	Nationality	Vehicle Origin	Number in 1983	Cumulative Total 1957-1982
Sapwood (A)	USSR	missile (SS-6)	46	923
Thor/Delta	USA	missile	8	367
Skean (C)	USSR	missile (SS-5)	23	266
Atlas	USA	missile	6	185
Sandal (B)	USSR	missile (SS-4)	0	144
Titan	USA	missile	3	135
Scarp (F)	USSR	missile (SS-9)	17	124
Proton (D)	USSR		12	81
Scout	USA		1	72
Saturn 5	USA		0	13
Saturn 1	USA		0	13
Mu	Japan		1	11
"N"	Japan	missile (Thor)	2	9
FB-1	China	missile (CSS-X4)	1	8
Diamant B	France		0	6
STS	USA		4	5
Redstone	USA	missile	0	4
Jupiter	USA	missile	0	4
Diamant	France		0	4
Vanguard	USA		0	3
Ariane	ESA		2	3
Long March 1	China	missile (CSS-2)	0	2
SLV-3	India		1	2
Lambda	Japan		0	1
Black Arrow	U.K.		0	1
Total			127	2,386

It is argued in the Western World that the Soviet Union sized its first ICBM before the thermonuclear breakthrough in weaponry allowed light weight hydrogen bomb warheads. Hence, it ended up with a large and uneconomic vehicle on its hands, while the United States was able to scale down the design size of Atlas and Titan missiles because of reductions in warhead weight. Whether this assessment is right or not, the consequence has been helpful to the Soviet space program. While the United States was building its IGY program around a 9-kilogram Vanguard, the Soviets were building a 1,327-kilogram Sputnik 3, and planning to do even more on lunar flights.

Until the Saturn family appeared in service, at each stage the Soviet Union was equipped with larger launch vehicles by far. The repetitive use of the standard (A) vehicle probably gave it good reliability. It is rugged, has a first stage of five sets of tanks, four of which fall away from the core vehicle early in flight. Each of the five segments has four rocket nozzles, plus separate steering nozzles.

By Soviet accounts, several of their launch vehicles use liquid oxygen and a kerosene derivative for the first stages (as do many of those of the United States), and use fairly conventional storable fuels for upper stages. There is no sign of a secret breakthrough in fuels, but their engines are run at a relatively high pressure, increasing efficiency.

The United States has developed solid-fuel rockets mostly for military missile purposes, and certain space upper stages. The small Scout rocket is solid fuel in all stages, and strap-on boosters of solid fuel are used with Titan IIIC, D, & E, and Augmented Thrust Thors.

The Soviet Union began to put large solid rocket missiles into its Moscow parades only in the last 15 years or so, well behind use of such

rockets in the United States. These have some missile use, but there is no clear sign that solid-fuel rockets have been used for Soviet space purposes.

The United States experimented with components for a nuclear rocket as an upper stage for Saturn. A solid core reactor would heat hydrogen to be expelled from the nozzle. Despite this long time development effort, the work has now been cancelled as an economy move.

The Soviet Union could be developing a nuclear rocket, but so little has been said to date by them in this regard that any opinion on the subject would be highly speculative. Probably it has a low priority today.

The Russians have issued publicity on electric rockets. These are used operationally for station-keeping in ocean electronic ferret space craft. They have not yet been used for deep space acceleration of payloads.

Looking at the upper range of national capabilities, the Saturn V clearly has been the best operational weight lifter in the world. The 3.4 million-kilogram-thrust Saturn V may be challenged by a Soviet vehicle in the 4.5 to 6.4 million-kilogram-thrust class unless this rocket, suspected to have failed three times, has been permanently retired. In 1981, however, the U.S. Department of Defense included a booster of this size in its list of impending Soviet accomplishments in the publication Soviet Military Power. The 1983 edition of this report included a drawing of this "heavy lift launch vehicle" as well as a smaller "medium lift" version (see figure 4).

The two major questions are when these new vehicles will be introduced, and what type of fuel they will use. At the end of 1983, reports were circulating in the trade press that a test launch of one or both of the

vehicles was imminent. If a test occurs in 1984, the vehicle(s) could be operational by 1985. As to fuel type, the Soviets still have not utilized high energy cryogenic fuels (liquid oxygen/liquid hydrogen) used by both the U.S. and Europeans. Although it is expected that at some point the Soviets will introduce launch vehicles with the higher efficiency cryogenic fuels, it would seem more likely that they would begin with upper stages rather than attempting to build an entire new launch vehicle using an untested (for them) fuel.

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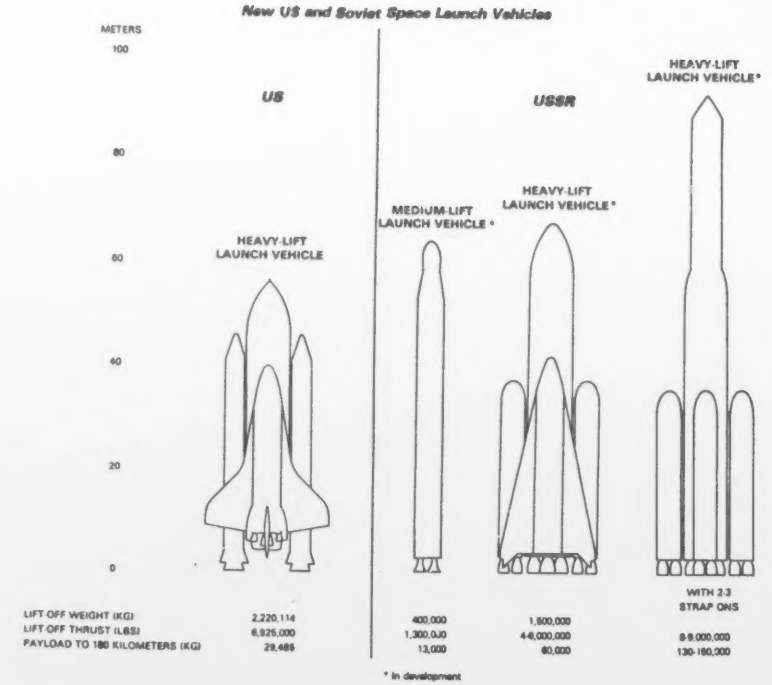
FIGURE 4



U.S. Department of Defense. Soviet Military Power. Washington, U.S. Govt. Print. Off., 1983. p. 68.

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CHAPTER SEVEN: FUTURE DIRECTIONS FOR THE SPACE PROGRAMS

Attempting to predict the future of the space program is a difficult assignment as it depends upon political decisions as much as on technical capabilities. At least, there are more engineering possibilities than there are financial resources likely to be made available to pursue them. The issue of future goals has been with the United States for several years, particularly after the accomplishment of the dominating Apollo mission.

Estimating what the Soviet Union will elect to do in space may be even harder for a Western observer because of Soviet restrictions on freedom of information. The United States abounds in paper plans, but until the President and the Congress agree on funding, U.S. plans stay on paper, and there is no formal commitment to go ahead. In the Soviet case, they have stated at several levels of authority, including the highest, more positively their long-run goals, although without a real, public timetable. They, too, undoubtedly have to face hard budget choices before actual hardware work can begin.

The announced Soviet goal is a comprehensive exploitation of space technology including the exploration and settlement (where practical) of the planets, along the way exploring the Moon in greater detail, and using Earth orbital stations for a host of practical purposes.

A. REUSABLE VEHICLES

The U.S. space shuttle was designed to be the national space launching system for all purposes--military, civil, and commercial. Because it is a reusable system, it is expected to reduce the costs associated with launches, but for the indefinite future, the U.S. Government will continue to subsidize launches to make shuttle prices competitive with other systems.

Uses of the shuttle have not been defined yet, either, other than for the routine launching of free-flying satellites for purposes such as communications, meteorology, science, and military reconnaissance. As noted elsewhere in this report, the 1969 space program plan for the United States which included the space shuttle also included a space station which would be serviced by the shuttle. Although the United States abandoned plans for a space station because of budgetary constraints within NASA, these plans are now being reconsidered (see section below on manned space stations).

Some of the possible uses of space which have been envisioned in the shuttle era include materials processing in space, and constructing large space structures which could incorporate the functions of several different types of satellites which are flown individually at the present time (such as communications and meteorological observations). There are also potential military uses of the space shuttle, including reconnaissance, although these plans have not been openly discussed.

The existing space shuttle is seen only as the first of an evolutionary series of manned and unmanned reuseable space vehicles. One concept under study at the present time is called SRB-X which would be an unmanned derivative of the shuttle for lifting very heavy payloads into orbit.

The U.S. Air Force is also studying the possibility of developing a spaceplane, or transatmospheric vehicle (TAV) as it is sometimes called, which would be a smaller version of the space shuttle and capable of being launched in a shorter period of time from many different sites around the world. The TAV could be launched from a conventional rocket, from an airplane, or from the cargo bay of the shuttle, depending upon its mission. Types of activities for a TAV include reconnaissance, and satellite inspection and repair.

The Soviet Union has shown an equal awareness of the potential of reusable vehicles, and various Soviet space officials have stated their own convictions that such development is essential. But in keeping with Soviet practice, internal debates, or even decisions without debate, about new technology are not exposed in any public forum, so the current status of the Soviet effort, if any, in this regard is not known. Considering the Soviet effort to maintain a position of leadership in space, and the continued high level of Soviet flight activity (over five times that of the United States), they have even more compelling reasons to develop a reusable shuttle as a cost saving device. It is hard to imagine their attainment of announced goals without use of a shuttle. As noted earlier, the 1982 flight of Kosmos 1374, and Kosmos 1445 and 1517 in 1983 are thought to have been related to this developmental effort, and the 1983 Soviet Military Power book by the U.S. Department of Defense states the existence of two Soviet reusable space vehicle development programs.

B. MANNED SPACE STATIONS

1. United States

After Apollo 17, the United States cancelled the three remaining Apollo lunar landing missions and made available for space station use a Saturn V

launch vehicle from the remaining small stockpile, after production of these launch vehicles had ceased. The space station, Skylab, was launched on a Saturn V in 1973 and was built in the shell of an S-IVB rocket stage. It was accompanied by an associated docking adapter, air lock, and telescope mount. After hosting three crews in 1973-1974, it decayed from orbit in 1979, with some debris recovered in Australia.

Plans for a military Manned Orbiting Laboratory (MOL) had been abandoned in 1969 because of budget squeeze and changing technology. Despite the similarity of name, this alternate program was to operate in so different a mode that it was never competitive with Skylab; the only common factor was that it would have been a manned space station.

In September 1969, a special task group reporting to the President recommended a four-element program for the 1970s which included the already described space shuttle, a versatile space tug for extensive maneuvering in orbit or landing on the Moon, a nuclear-powered rocket ferry for transfers between Earth orbit and lunar or planetary orbits, and a building block system of modules to construct permanent space stations in Earth orbit, and elsewhere. The program was carefully considered technologically, but it involved fiscal peaking problems which were given small chance of winning general national support. Hence, construction of the shuttle is the only one of the four elements recommended by the Nixon Administration for active development (aside from solid-fuel upper stages) that has gone forward to date.

Part of the gap in the U.S. program will be filled by the Europeans who have built a manned sortie module (Spacelab) to be carried in the shuttle.

It will not be detached from its shuttle ferry, however, so is not a real substitute for a space station, although the Europeans are proposing using several Spacelab modules docked together as a space station option.

In early 1984, President Reagan is expected to make a decision as to whether or not NASA should build a space station to provide a permanent U.S. manned presence in orbit as the Nation's next major space initiative. Support for a space station has not been forthcoming from potential space station users, however. The space science and space applications communities are concerned that the funding requirements for a space station ($8 billion for an initial station which could be operating by 1992) would prevent other projects in their fields from being approved by the agency, and feel that their needs can be met by the space shuttle and unmanned spacecraft. DOD states that it has no mission requirements that could not be conducted less expensively and just as effectively on unmanned spacecraft, but adds that if "someone else" develops a space station, they will certainly consider using it. Supporters of the space station concept insist that many uses will be found once the station exists, and that it is needed to maintain U.S. preeminence in space.

Based on NASA studies conducted for the past several years, the most likely configuration for a U.S. space station is not a single structure, but rather a series of platforms, some manned and others unmanned, co-located in orbit. This would provide versatility in the types of processes and experiments that could be conducted, since some suffer interference when people are in the vicinity (like materials processing and astronomical observations which would be impacted by vibrations caused by crew motions).

2. Soviet Union

The Soviet Union claimed that its docked combination of Soyuz 4 and 5 in January 1969 represented a rudimentary space station, inasmuch as there were four rooms assembled with four men present. But the ships were docked only a few hours, and the transfer of crews had to be done by EVA, rather than crawling through a connecting tunnel. The ASTP had a slightly better claim to such a label, when five men could visit directly through air locks.

The Salyut space stations can make a real claim to their title, even though the 18,600 kilogram weight and 90 cubic meters of interior space (without Soyuz) fall well short of the 77,110 kilograms and 275 cubic meters of Skylab (without Apollo). The advantage of Salyut is that it is an on-going and evolving program. The 31 successful flights (manned and unmanned) which docked with Salyut 6, followed by Salyut 7 with its 11 manned and unmanned dockings so far, have borne this out.

For the future, the Russians speak confidently of building a large and permanent orbital station for many people, for the purpose both of conducting Earth applications work and scientific observation of the stars, and additionally serving as an orbital assembly, checkout, and launch facility to send manned expeditions to the Moon and planets. Keldysh, then President of the Soviet Academy of Sciences, predicted in October 1969 that such a large station might be ten years away but would more likely be available in five years, but by the end of 1983 still had not been launched. It may be that the long awaited large (G) launch vehicle will find use in lifting major components for such a station. At the moment, orbital assembly of small components seems a more likely path.

In 1983, for example, the Soviets discussed the possibility of launching a module specially designed for materials processing research to dock with a space station (presumably Salyut 7). Such a development in 1984 would not be surprising, and, in fact, they might dock the module with Salyut 7 only long enough for the crews to emplace the samples to be processed. The module could then undock so crew motions would not interfere with the processing, and redock once the experiments were completed to enable the crew to remove the processed samples and install new ones.

A November 28, 1983 article in Pravda outlined Soviet space station goals beyond those described by Keldysh. The article, by President of the Ukraininan Academy of Sciences B. Baton and Soviet Doctor of Technical Sciences Y. Semenov, described a complex of installations in altitudes ranging from 200 to 4,000 kilometers linked to Earth by freight and passenger transport spacecraft. The complex would have specialized modules for scientific research, living quarters, power generation, refueling, repair workshops, and construction sites for producing and installing standardized construction components. No time frame was given for when such a complex might begin to be put in place.

There is more press and professional discussion world-wide than firm planning for space colonies. A favorite scheme is the L-5 proposal popular in the United States for a 10,000 person colony to be positioned in Earth orbit as far away as the Moon at a Lagrangian point (where the gravitational forces of the Earth and Moon cancel each other out).

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C. PROSPECTS FOR FUTURE MANNED FLIGHTS TO THE MOON

Following the six successful Apollo landings on the Moon, U.S. interest in continuing the program waned to the point that three additional landings (Apollo 18-20) were cancelled. In addition, there have been no U.S. unmanned lunar flights since the Apollo era. During the rest of the 1970's, little was said about future U. S. manned lunar missions and even unmanned programs, such as the proposed Lunar Polar Orbiter, could not muster sufficient support to win inclusion in Administration budget requests to Congress. At the end of 1983, however, there were rumors that President Reagan may include a manned lunar base as a long term goal in his National Space Strategy, expected to be unveiled in 1984.

The Soviet Union, after losing the Moon race to the United States, continued unmanned Luna missions until 1976. Since that time, however, there has been little discussion of Soviet lunar plans. Nevertheless, it would not be unexpected to see the Soviets eventually send crews to the Moon, since their goals in space are so broad and long range. If western analysts are correct that the Soviets lost the Moon race because they did not have hardware capable of accomplishing the task, then the attempt might be made once hardware (for example the large G booster and high energy upper stages) becomes available.

D. PROSPECTS FOR MANNED FLIGHTS TO THE PLANETS

1. United States

For a number of years, NASA studied various kinds of manned planetary expeditions, principally to Mars. Briefly, there was interest in the early 1960s in a fly-by of Mars and possibly of Venus by the late 1970s, using modified Apollo and Saturn V equipment, but this was not seriously entertained in any formal program. When the President's Space Task Group in the summer of 1969 submitted its long range U.S. space plan, it opened the possibility of a Mars landing by men in the 1980s. The general reaction in the Congress with few exceptions was either indifference or active hostility, and NASA has not pressed this possibility in its official plans.

As mentioned earlier in this paper, a U.S. capability to use space in the late 1970s and thereafter was to be built around use of four types of largely reusable and multipurpose vehicles. The shuttle, already discussed, was the first and most vital. It is important to recognize that the shuttle was not intended to be an end in itself, but represented a design approach to cutting costs and adding capacity for all kinds of missions, whether unmanned, or manned, and whether in Earth orbit or beyond. The second element, already discussed, was the manned station module. This was expected to justify its costs of development and use in practical applications in Earth orbit once such a reliable unit was available, and the shuttle permitted non-astronauts and less expensive payloads to fly to and from orbit safely at more moderate cost. Purely as a dividend, such a unit could also have

been used at nominal additional cost in orbit around the Moon, on the surface of the Moon, or for flight to the planets.

A third element was a space tug, to have been used in assembling components in the vicinity of the future permanent space station, shifting payloads to synchronous orbit, or landing major components on the Moon as successor to the transport capabilities of the Apollo lunar module.

Only the fourth element of the proposed national program was aimed primarily at deep space work: the nuclear-powered orbital transfer shuttle, also reusable, both for major movements to and from the Moon or in planetary flight. (All U.S. nuclear propulsion development was halted in the early 1970s.)

When some Members of Congress reacted very negatively to the report of the Space Task Group, the very existence of the shuttle, which was intended to be so important to cutting costs near Earth, was threatened by the charge that it represented a back-door attempt to gain a manned planetary program without explicit approval. Consequently, little has been said about planetary flight since then by NASA in connection with the shuttle or other program elements.

When the United States decided to send men to the Moon, it had to construct an entirely new capability whose cost totaled $21.35 billion up through the first landing. Successive flights were priced at $450 million or so, once the initial investment had been made. It was not surprising, in discussing the much greater challenge of manned planetary flight, that it soon became common in political circles to put a $100 billion price tag on a first expedition to Mars. Considering that equipment would have to work reliably for about

two years instead of two weeks, the needed redundancy for safety as well as the initial logistics requirements would add up to a fairly ambitious undertaking if the Saturn V and Apollo technology of 1961 were to be used. Human health reactions on such a long flight have also been questioned, despite some partial long-duration tests of closed cabins on Earth, as well as use of the Skylab flights.

The motivation for the Space Task Force plan was by no means exclusively for creating a capability to fly to Mars; but perhaps the number of words devoted to the subject in the report, related in part to sounding out public support for an inspiring new goal, was misplaced in the climate of apathy and even hostility which followed so quickly after the Apollo 11 success.

The marginal cost per kilogram of payload by using the shuttle to attain Earth orbit was originally expected to drop from $1,500 to about $330 in the first generation of this class. This cost advantage has largely eroded away, but there is still hope of at least breaking even with expendable vehicles on launch costs. However, the shuttle also affords major opportunities to cut the cost of payloads through changing the flight environment, removing the extreme cost sensitivity to launch weight, and permitting recovery and repair of expensive payloads.

The shuttle justification was built almost entirely around these economic data for Earth applications. Yet it is true that the potential will be created for more distant flights as well. For example, the estimate is that Apollo/Saturn V hardware had an operating cost for round trips to the Moon of $80,000 per kilogram. With the four new elements of the Space Task

Group plan, this operating cost would have fallen to about $800 per kilogram, or only one percent as much. (All figures have to be adjusted for inflation.) In similar fashion, planetary flights fall drastically in cost, and even allowing for all the special payloads that might be required, a Mars expedition in the late 1980s might be priced at a figure far closer to $10 billion (1971 dollars) than to the former estimate of $100 billion (1971 dollars). This is not a question which must be decided now, but as elements of the four types of reusable vehicles may be added to the national capability, each justified on other grounds, we may find that we have kept our options open for this later period in our history.

2. Soviet Union

As already indicated, the Soviet Union has talked more positively about manned flight to the planets and it is hard to doubt their ultimate intentions in this regard as one studies their total program effort. Carrying out such flights will face them with the same technical and financial questions which the United States will have. Nevertheless, they have frequently stated that one of the reasons they want to extend the duration of manned missions in Earth orbit is to obtain data on human reaction to spaceflight conditions so someday they can send men to Mars (although they have never said they would land them on the planet).

3. Summary

This brief review does not assess the ultimate consequences of pursuit of such goals or failure to undertake them. Some people are already

convinced that no set of circumstances would warrant the effort. Others are hardly deterred by the difficulties, expense, or uncertain results. It is hard to accept philosophically that mankind would forever exclude the possibility of visiting most parts of the Solar System. The late President Eisenhower saw practical reasons for limiting space expenditures, but even his first public report on space goals accepted in principle flights by men to Mars, as have most other U.S. Presidents since that time.

E. COOPERATION BETWEEN THE UNITED STATES AND SOVIET UNION

While the main feature of the relationship between the United States and Soviet Union has been competition, the two countries have also cooperated throughout the years as well. The most long-standing and successful cooperative arrangements have involved the exchange of scientific data from planetary programs, and of space biology information. The Soviets have launched four biosatellite missions (in 1975, 1977, 1979, and 1983 respectively) which have carried U.S. experiments. Five major treaties concerning space activities have been negotiated at the United Nations and signed by both countries.

Two principal motives for cooperation offered have been to lessen tensions politically, and to save money. The question of tensions may be more influenced by broader political issues than technical cooperation. Money savings are problematical, except as someday sharing of data might permit a division of missions as between one planet and another, for example. Useful also are the proposed biomedical data exchanges.

The question in the 1960s of whether the Russians and Americans could go to the Moon together was asked more in a rhetorical sense than as a concrete offer by either side. Each side probably was somewhat reluctant to pursue such a goal too openly during any period that one or the other was markedly ahead. Nor has either been willing to give up any basic, independent capability to operate in space, which might be implied by such a division of labor as specialization in launch vehicles or spacecraft.

The future of U.S./Soviet cooperation has been clouded by international tensions. After the imposition of martial law in Poland in late 1981, President Reagan announced sanctions against the Soviet Union for the role it is believed to have played in that situation. Among the actions taken by Reagan was the announcement that the United States would not renew scientific agreements with the Soviet Union, including the space cooperation agreement which expired in May 1982. Two projects (the biosatellite mission launched in 1983 and a joint search and rescue satellite program) which were begun while the agreement was in force will be continued, however, and both countries are cooperating with the European Space Agency and Japan in ground- and space-based studies of Halley's Comet. For example, NASA will track the Soviet VEGA spacecraft to provide targeting data to ESA for the Giotto Mission.

F. POLICY ISSUES FOR THE 1980s

The overall space policy of the United States is embodied in the 1958 National Aeronautics and Space Act. Through the 1960s, the country focussed its efforts on meeting the 1961 goal established by President Kennedy to land men on the Moon by the end of the decade. As discussed previously, a panel

was established near the end of the 1960s to establish goals for the U.S. space program following completion of the Apollo program, but only the space shuttle remains of those ambitious proposals.

During the 1970s, the executive branch proposed no major space mission initiatives of the order of magnitude of the Apollo program. In 1978, President Carter issued two space policy directives in an attempt to give guidance to the U.S. space effort, but they were subsequently criticized for not proposing specific programs. Congress responded with the introduction of several bills to specify programs which could be accomplished in the next 10 to 30 years, but none was reported from committee. President Reagan issued his own space policy on July 4, 1982. The directive reiterated U.S. policy to maintain separate military and civil space programs, but was criticized for seeming to place more emphasis on military uses of space.

As already described, the space shuttle has absorbed a very large portion of the available funds, and the policies of making do with limited funds have stretched the program extra years and run up total costs. There have been arguments over how many space shuttle orbiters should be built, and whether there will be payloads to fill them. Currently, all flight space is booked on available shuttles through 1987, with some payloads having to be diverted to expendable rockets, both American and European, to meet critical user deadlines.

In the applications area, a principal development has been the growing number of communications satellites, so that a potential shortage of "parking" spaces along the Equator has become a matter of domestic and international contention. Another principal development has been to find a way of moving to an operational Earth resources satellite system, with many different options for ownership, management, and systems design.

The proposal to meet energy shortages caused by limits to available fossil fuels by building solar power satellites attracted some interest from 1977-1981. Large collectors of sunlight in high orbit would convert solar energy to microwave or laser form for transmission to Earth where it would be transformed into electric power. Industrial groups pushed energetically for demonstration projects, if not full scale development, while environmentalists raised many questions about side effects, and other analysts have questioned the cost/benefit potentials as compared with greater exploitation of less-utilized fossil fuel sources, bio-mass sources, nuclear energy, and ground-based primary solar collectors. Government studies completed in 1980 and 1981 explored these issues, but did not resolve them. No funding has been provided for development of this concept since 1981.

In the area of space science, a backlog of projects suggested by advisory panels remains unfunded. A Space Telescope to be carried in the shuttle will be launched in 1985, and plans are underway for a Gamma Ray Observatory to be launched in 1988. After the spectacular achievements of the Viking missions to Mars, Pioneer missions to Venus, and Voyager missions to Jupiter and Saturn, a gap of at least five years has developed in future planetary exploration. The VOIR mission for the further mapping and exploration of Venus has been cancelled (although a scaled-down version was included in NASA's FY84 budget request), and Galileo, the Jupiter orbiter and probe mission, is the only surviving U.S. planetary mission in development. The United States decided not to take advantage of the once-in-almost-a-century opportunity to probe Halley's Comet; it will be explored by the European Space Agency, the Soviet Union, and Japan, without direct U.S. participation.

The Administration and the Congress will not lack for difficult and perplexing choices related to space missions, and to the level of activity which is appropriate. The decisions will be made more difficult by lack of agreed upon facts as to the current, intermediate, and long term payoffs in economic benefits, national defense, and understanding of nature, on which, presumably, human well-being may depend as energy needs become harder to meet, and the environment is further threatened by man's activities.

In FY82, space expenditures in DOD surpassed NASA's space budget for the first time and by FY84, was 32 percent larger ($9.9 billion for DOD space activities compare to $6.7 for NASA space activities). In fact, the DOD space budget would be even larger if NASA-funded development of the space shuttle was taken into account (DOD is expected to require two of the four authorized space shuttle orbiters for its operations). Since NASA is a research and development agency, it is not expected to be the operator of the shuttle system once it is completely developed, and one possibility is that DOD will operate it for all users--civil, military, and commercial. Another possibility is that DOD would operate it only for Government missions, while a private sector group would be in charge of commercial and foreign users.

If no major civil space intiative is identified for NASA in the 1980s, the agency would have little to do other than space science programs, since the Reagan Administration is proposing to transfer most space applications programs to the private sector. Under these circumstances, some are concerned that the Administration will recommend that NASA be abolished, with the space science activities taken over by another agency such as the National Science Foundation. The pending Presidential decision on whether or not to build a space station may clarify these issues.

In contrast to the U.S. situation, the 1980s could be a period of substantial achievement by the Soviet Union including permanent occupancy of expanding manned orbital facilities with a capacity to support industrial and resource applications. It would not be unexpected if the Soviets launch a reusable spacecraft during the 1980s. It would be difficult to conclude these achievements will not have impacts on U.S. policy toward space.

CHAPTER EIGHT: TABLE OF SPACE "FIRSTS" -- U.S. AND SOVIET

Any attempt in simple form to compare the relative pace of the two principal space programs through a table of firsts has certain weaknesses, as it does not answer by how many days or years a particular event occurred in one country before another. Further, it does not distinguish between a nominal first accomplishment in crude form by one country, sometimes followed by a much more impressive and elaborate follow-up by the other country. Nonetheless, such firsts do affect public opinion, and analysis by various fields of endeavor may give some sense of relative direction of pacing efforts in each country. The table which follows attempts such a measure:

TABLE 9. Major U.S. and Soviet Space "Firsts"

United States			Union of Soviet Socialist Republics		
Event	Satellite	Launch Date	Event	Satellite	Launch Date
Science			Science		
Van Allen radiation belts	Explorer 1	02/01/58	Orbiting geophysical lab	Sputnik 3	05/15/58
Earth shape measured	Vanguard 1	03/17/58	Farside lunar picture	Luna 3	10/04/59
Orbiting solar observatory	OSO 1	03/07/62	Cosmic ray measurements	Proton 1	07/16/65
Data from Venus	Mariner 2	08/27/62	Pictures from lunar surface	Luna 9	01/31/66
Geodetic satellite	Anna 1B	10/31/62	Lunar surface bearing test	Luna 13	12/21/66
Lunar close-up pictures	Ranger 7	07/28/64	Venus atmospheric probe	Venera 4	06/12/67
Mars pictures	Mariner 4	11/28/64	Automated return of lunar sample	Luna 16	09/12/70
Micrometeorite satellite	Pegasus 1	02/16/65	Automated lunar roving laboratory	Luna 17	11/10/70
Lunar orbit pictures	Orbiter 1	08/10/66	Venus soil analysis	Venera 8	03/27/72
Lunar trenching	Surveyor 3	04/17/67	Venus surface pictures	Venera 9	06/08/75
Color picture of full Earth face	DODGE	07/01/67	Radio telescope 10-meter dish	Salyut 6	09/29/77
Lunar soil chemical analysis	Surveyor 5	09/08/67			
Point-stabilized Orbiting Astro-Observatory	OAO 2	12/07/68			
Live lunar TV broadcast	Apollo 8	12/21/68			
Return of lunar rocks	Apollo 11	07/16/69			
Long life lunar surface sensors	Apollo 12	11/14/69			
Color pictures of Jupiter	Pioneer 10	03/03/72			
Color pictures of Saturn	Pioneer 11	04/06/73			
Radiotelescope, far side Moon	Explorer 49	06/10/73			
Pictures of Venus	Mariner 10	11/03/73			
Pictures of Mercury	Mariner 10	11/03/73			
Solar Probe	Helios 1	12/10/74			
Mars surface pictures	Viking 1	08/22/75			
High energy astro observatory	HEAO 1	08/12/77			
Detailed Jupiter Moons surveys	Voyager 1	09/05/77			
Detailed Saturn Moons surveys	Voyager 1	09/05/77			

TABLE 9. Major U.S. and Soviet Space "Firsts"--continued

United States			Union of Soviet Socialist Republics		
Event	Satellite	Launch Date	Event	Satellite	Launch Date
Applications			**Applications**		
Active communications	Score	12/18/58	Domestic communications	Molniya 1-1	04/23/65
TV pictures from space	Explorer 6	08/07/59	Fractional orbit bombardment	Kosmos 139	01/25/67
Weather satellite	Tiros 1	04/01/60	Antisatellite test	Kosmos 248 & 249	10/20/68
Navigation satellite	Transit 1B	04/13/60	Radar ocean surveillance	Kosmos 626?	12/29/73
Missile detection	Midas 2	05/24/60			
Observation recoverable flight	Discoverer 13	08/10/60			
Passive communications	Echo 1	08/12/60			
Operational synchronous communications	Syncom II	07/26/63			
Nuclear explosion detection	Vela Hotel	10/17/63			
Earth resources satellite	ERTS 1	07/23/72			
Synchronous 24-hour weather	SMS 1	05/17/74			
Commercial maritime communications	Marisat 1	02/19/76			
Sea resources satellite	SeaSat 1	06/27/78			
Bio and Manned Flight			**Bio and Manned Flight**		
Manned orbital maneuver	Gemini 3	03/23/65	Biosatellite	Sputnik 2	11/03/57
Controlled extravehicular activity	Gemini 4	06/03/65	Recovery, orbited animals	Korabl Sputnik 2	08/19/60
Manned space rendezvous	Gemini 6, 7	12/04/65	Recovery orbited man	Vostok 1	04/12/61
Manned docking	Gemini 8-Agena	03/16/66	Multi-manned spacecraft	Voskhod 1	10/12/64
			Extravehicular activity	Voskhod 2	03/18/65
Manned lunar orbit	Apollo 8	12/21/68	Recovery, circumlunar live animals	Zond 5	09/21/68
Manned lunar return reentry	Apollo 8	12/21/68	Transfer crew between ships	Soyuz 4-5	1/14-15/59
Lunar orbit rendezvous	Apollo 10	05/18/69	18-day flight	Soyuz 9	06/01/70
Lunar landing and return	Apollo 11	07/16/69	Space station	Salyut 1	04/19/71
Lunar pinpoint landing	Apollo 12	11/14/69			
Manned lunar rover	Apollo 15	07/26/71			

TABLE 9. Major U.S. and Soviet Space "Firsts"--continued

United States			Union of Soviet Socialist Republics		
Event	Satellite	Launch Date	Event	Satellite	Launch Date
Bio and Manned Flight			**Bio and Manned Flight**		
28-day flight	Skylab 2	05/25/73	24-day flight	Soyuz 11	06/06/71
59-day flight	Skylab 3	07/28/73	International docking	Soyuz 19	07/15/75
84-day flight	Skylab 4	11/16/73	2 ferry craft docked to station	Soyuz 26/27	01/10/78
International docking	Apollo	07/15/75	96-day flight	Soyuz 26/27	12/10/78
Flight of reusable vehicle	STS 1	04/12/81	International crew launch	Soyuz 2	03/02/78
4-person crew	STS 5	11/11/82	140-day flight	Soyuz 29/31	06/15/78
5-person crew	STS 7	06/18/83	175-day flight	Soyuz 32/34	02/25/79
6-person crew	STS 9	11/28/83	185-day flight	Soyuz 35/37	04/09/80
			211-day flight	Soyuz T-5/T-7	05/13/82
			Construction in space	Soyuz T-9	11/01/83
Space Flight and Propulsion			**Space Flight and Propulsion**		
Multiple spacecraft payload	Transit/ Solrad	06/22/60	Space flight	Sputnik 1	10/04/57
Payload recovery	Discoverer 13	08/10/60	Earth escape spacecraft	Luna 1	01/02/59
			Lunar impact	Luna 2	09/12/59
			Orbital platform launch	Sputnik 5	02/12/61
			Venus flyby	Venera 1	02/12/61
Hydrogen rocket orbited	Centaur 2	11/27/63	Mars flyby	Mars 1	11/02/62
Docked spacecraft maneuver	Gemini 10-Agena	07/18/66	Venus impact	Venera 3	11/16/65
			Lunar soft landing	Luna 9	01/31/66
Lunar-velocity reentry	Apollo 4	11/09/67	Lunar orbiter	Luna 10	03/31/66
Constant deceleration reentry	Apollo 8	12/21/68	Automatic docking	Kosmos 186/188	10/27-29/67
Mars orbit	Mariner 9	05/30/71	Recovery, lunar payload	Zond 5	09/21/68
Jupiter flyby	Pioneer 10	03/03/72	Skip reentry lunar payload	Zond 6	11/10/68
Solar system escape	Pioneer 10	03/03/72	Venus soft landing	Venera 7	07/17/70
Venus/Mercury flyby	Pioneer 10	11/03/73	Mars impact	Mars 2	05/19/71
Jupiter/Saturn flyby	Pioneer 11	04/05/73	Mars soft landing	Mars 3	05/28/71
Libration point halo orbit	ISEE 3	08/12/78	Venus orbit	Venera 9	06/18/75
			Automatic propellant transfer	Progress 1	01/20/78

TABLE 9. Major U.S. and Soviet Space "Firsts"--continued

United States			Union of Soviet Socialist Republics		
Event	Satellite	Launch Date	Event	Satellite	Launch Date
Auxiliary Power Systems			Auxiliary Power Systems		
Solar cells	Vanguard 1	03/17/58	Battery power	Sputnik 1	10/04/57
Isotope power	Transit 4A	06/29/61			
Nuclear reactor in orbit	Snapshot 1	04/03/65			
Fuel cell	Gemini 5	08/21/65			

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PART TWO

SPACE ACTIVITIES OF OTHER LAUNCHING COUNTRIES/ORGANIZATIONS

Until 1982, this report included text only on the space activities of the United States and Soviet Union, although launch activities of other nations were noted in the various tables. The 1980s are likely to witness the emergence of at least four additional launching countries/ organizations, so these have now been added: China, the European Space Agency (a group of eleven European nations), India, and Japan.

Four other countries--Australia, France, Italy, and the United Kingdom--are sometimes also referred as launcher countries, Australia and Italy because of the launch facilities they have operated, and France and the United Kingdom because of the launch vehicles they developed in the past. Neither the French Diamant or the British Black Arrow are in use any more, however, so they are not included in this discussion. The Australian launch facilities at Woomera are no longer in operation, and although the Italian-operated San Marco platform off the coast of Kenya is used occassionally, it does not involve use of Italian launch vehicles, so Italy is not included either.

A number of countries other than the United States and Soviet Union have significant national space programs, including France and Germany which also participate in space activities as members of the European Space Agency. This report does not include these national programs because of space and time

considerations, but an extensive treatment of the space activities of all countries in the world except the United States and the Soviet Union can be found in the report World-Wide Space Activities, prepared by the Science Policy Research Division of the Congressional Research Service for the House Committee on Science and Technology. Since that report covers the years through 1977, the following overview of the Chinese, ESA, Indian and Japanese space programs will focus on the period since then. This overview is not intended to be an exhaustive treatment of the space activities of these countries, but only to provide general information and trends. Tables 1, 7, and 8 provide statistics on annual launches made by these countries.

CHAPTER ONE: CHINA

China launched its first satellite in 1970. Since then, it has made a total of ten launches, placing thirteen satellites in orbit. Of these, five spacecraft have been recovered, and are thought to be related to development of a reconnaissance satellite capability (recovery is necessary for film-type reconnaissance satellites). The others have had scientific missions, including a launch in 1981 which placed three spacecraft into orbit simultaneously. In 1983, the Chinese launched one satellite, China 13, which was recovered and therefore is thought to be part of its reconnaissance satellite development effort.

The Chinese have stated that they are developing a launch vehicle which will use cryogenic fuels (liquid oxygen/liquid hydrogen) for placing communications satellites in geostationary orbit (GEO). If they are successful, they will become only the third entity to have such a vehicle (after the United States and ESA), although Japan is also developing a cryogenic booster. The Chinese report that the vehicle, called the CZ-3 (or Long March 3) will be capable of placing 800-900 kilogram payloads into GEO. Early in 1983, a Chinese newspaper reported that the CZ-3 would be tested that year, but the report was later "corrected" and the reference to 1983 deleted. No date has since been mentioned for a test of the vehicle.

During 1979 and 1980, the Chinese expressed great plans for utilization of space, and even had astronauts in training for a time. In late 1980 and early 1981, however, the Chinese pulled back from their expansive plans because of a reassessment of the Chinese economic situation. Agreements to purchase broadcasting satellites from the United States were cancelled, and the Chinese announced that its manned space program had also been dropped at least for the remainder of the decade. Since that time, they have indicated that rather than buying broadcast satellites from abroad, they will develop their own.

The Chinese are apparently continuing with plans to purchase a Landsat receiving station from the United States, which may also be able to receive data from the planned French SPOT earth resources satellite, planned for launch in 1985. Difficulties have arisen because of U.S. concerns about exporting technology that could be used by the military sector, so the sale is not yet definite.

The Chinese launch vehicles, like those of the United States and Soviet Union, have been developed from military rockets. The advent of the Long March 3 launch vehicle would also indicate that the Chinese have a significant ICBM capability. It is thought that the ICBM version of this vehicle was tested during 1980. Several of the Chinese satellites launched to date are thought to be related to the development of military reconnaissance satellites.

CHAPTER TWO: EUROPEAN SPACE AGENCY

The European Space Agency (ESA) is a group of eleven European nations (with two associate members). ESA was formed in 1975 by the merger of the European Scientific Research Organization and the European Launch Development Organization. The members of ESA are: Belgium, Denmark, France, Federal Republic of Germany, Ireland, Italy, Netherlands, Spain, Sweden, Switzerland, and the United Kingdom. Austria and Norway are the associate members.

Since 1977, a major ESA activity has been development of an independent launch capability. In 1981, ESA successfully completed the third and fourth test flights of the Ariane launch vehicle, and declared the system operational, but the first operational launch, in September 1982, failed and its two communications satellites were dumped into the ocean. (The first test launch in 1979 was also successful, although the second test, in 1980, failed.) Two launches were successfully conducted in 1983, which placed three communications satellites in orbit. France has played the lead role in developing Ariane.

Ariane may have important ramifications for U.S. space policy because it will compete directly for commercial traffic with the space shuttle. Ariane can lift 1,780 kilograms into geostationary orbit, or two conventionally sized satellites, thereby reducing costs to the users. The Europeans also offer attractive financing plans where the user makes a relatively small down payment, and then does not have to pay the balance until six months after launch, when the satellite is producing revenue for the user. By

contrast, users must pay all costs in advance for launches via U.S. boosters, whether the expendable type such as Delta or Atlas-Centaur, or by the space shuttle. In 1981, three U.S. companies which had planned to use the shuttle switched to Ariane instead (GTE, Southern Pacific, and Western Union), but since then arrangements have been made so that several of the satellites involved could be launched on either Ariane or shuttle. Ariane is marketed by a private organization called Arianespace based in France.

ESA has approved plans to proceed with further development of the Ariane design, including a version which could send probes into interplanetary space or to the planets.

ESA's space activities encompass a wide range of science and applications satellites, and its programs have involved a considerable degree of cooperation with the United States. This cooperation has resulted in some discord, however, because of budget constraints within NASA which led to cancellation of the U.S. half of a joint project called the International Solar Polar Mission (ISPM). Originally, ISPM would have involved the launch of two probes to simultaneously study the north and south poles of the Sun. ESA and NASA would each have provided one spacecraft, and NASA would have supplied the power unit (a radioisotope thermal generator), launch, and tracking for both probes. In 1981, the United States unilaterally abrogated the memorandum of understanding with ESA on ISPM, prompting formal statements of displeasure from several ESA member countries to the U.S. State Department. Nevertheless, the mission could not be accommodated within NASA's budget, and the U.S. spacecraft was cancelled. NASA has promised to keep its commitment to provide the power unit, launch, and tracking for the ESA spacecraft, however.

Relations between NASA and ESA have cooled slightly because of the ISPM incident, but it seems likely that the two agencies will continue to develop certain programs jointly. For example, ESA is reportedly discussing the possibility of using some of its Spacelab modules to construct an orbiting space station in cooperation with NASA. Spacelab, a major cooperative venture between ESA and NASA, is a scientific laboratory which can be carried inside the cargo bay of the space shuttle, thereby providing a "shirt-sleeve" environment for performing a wide variety of experiments. Spacelab pallets have also been developed by ESA for use outside the habitable module for those experiments which require exposure to the space environment. The first Spacelab module was turned over to NASA in December 1981, and was launched in November 1983. The crew included an ESA astronaut, Ulf Merbold of West Germany, the first non-American to fly on an American manned mission.

ESA is proceeding with follow-on development of Spacelab. In addition to the space station concept mentioned earlier, ESA is also improving Spacelab to provide for durations of up to one month in orbit, and constructing an automatic space platform for Spacelab pallets.

Among ESA's other ongoing programs is the Giotto project to send a probe to intercept Halley's comet when it returns to the Earth's vicinity in 1985-1986. A proposal to send a U.S. probe to the comet was dropped because of budget constraints, and ESA later rejected a NASA proposal for a joint ESA/NASA comet mission. The Soviet Union and Japan are also sending probes to Halley's comet and an agreement between the three entities is being negotiated to provide for exchange of data from the missions. ESA also is developing an earth orbiting astronomical observatory called

Hipparchos for launch in 1986, and an X-ray astronomy satellite called EXOSAT for launch probably in 1982. The agency has approved plans for a project called L-Sat, an experimental multi-purpose communications and broadcasting satellite.

CHAPTER THREE: INDIA

India has been involved in developing satellites and launch vehicles for many years. Its first satellite, Aryabhata, was launched by the Soviet Union in 1975. While cooperation with the Soviets has continued (they launched two remote sensing satellites, Bhaskara 1 and 2, for the Indians in 1979 and 1981 respectively), India has also pursued development of an independent launching capability.

The first test launch of the Indian booster SLV-3 failed in August 1979. The Indians achieved success with their second test launch on July 18, 1980, however, which placed the Indian satellite Rohini 1 into Earth orbit (it remained in orbit until July 1981, longer than expected). The third SLV-3 flight took place on May 31, 1981, and although it succeeded in placing Rohini 2 into orbit, the altitude was lower than planned and the satellite decayed after only 9 days (instead of the expected 300 days). These Rohini satellites are primarily for monitoring the performance of the launch vehicle, although Rohini 2 also carried remote sensing equipment. In 1983, the Indians orbited Rohini 3 and announced it was for Earth resources studies. Some Western sources have suggested that the Indians are attempting to develop a military reconnaissance capability.

The Indians also built a communications satellite, APPLE, which was launched by ESA on the third Ariane test flight in June 1981. One of the

solar panels did not deploy properly, but the satellite operated with reduced power for two years.

In April 1982, the United States launched INSAT 1A for the Indians. The satellite had three functions: meteorology, voice and data transmissions, and direct broadcast transmissions. Several problems developed with the satellite once it was in orbit (the solar sail did not deploy at all, and the C-band antenna would not deploy for several weeks). The satellite was eventually declared operational, but by September its fuel supply (which should have lasted for many years) was exhausted, apparently because an open valve allowed the fuel to escape. The back-up satellite, INSAT 1B, was launched by the space shuttle in 1983 and has been declared operational.

Western press reports have indicated that India plans to spend approximately $400 million on its space activities between 1982 and 1985, and another $500 million between 1985 and 1990. The focus of the Indian space program is development of launch vehicles, communications, remote sensing, and meteorological satellites. India has also accepted an invitation from the Soviet Union to send an Indian cosmonaut into space (the Soviets have already launched representatives from the nine Interkosmos countries and a Frenchman). This flight is expected in April 1984.

CHAPTER FOUR: JAPAN

Over the past several years, Japan has released space program plans for the future which involve a very ambitious level of activity for that nation, including the possibility of launching astronauts on the U.S. space shuttle and possibly developing its own manned program. To date, however, the Japanese space program has focused on development of launch vehicles, and communications, weather, and scientific satellites.

Japan uses a mixture of U.S. and Japanese technology in its space activities. More than 20 satellites have been orbited by Japan, some of which were purchased from U.S. aerospace companies, while others were built by Japan. During the early years of the program, most orbital launches were provided by the United States, although at the present time Japan relies on launch vehicles which are manufactured in Japan under license from the McDonnell-Douglas Corp. The vehicle, called "N" booster, is based on the Delta rocket developed by that company.

Japan is also likely to offer stiff competition to the United States, although unlike ESA, it is not likely to be in terms of providing launch services. Rather, Japan seems likely to compete in the area of space technology itself, particularly communications satellites.

In 1977, the Japanese launched the first experimental communication satellite to operate at the frequencies of 30/20 Gigahertz. Most communication satellites today operate at lower frequencies, and those bands are

becoming congested; 30/20 GHz technology is anticipated to be the wave of the future. In the United States, policy disputes over whether the Government or private industry should pay for developing advanced communication satellite technology such as this has slowed development of U.S. technology, while the Japanese have forged ahead. Their first operational 30/20 GHz satellite, CS 2, was launched in February 1983.

Development of communications satellites in Japan did not take place without difficulties, however. In 1979 and 1980, Japan lost two communications satellites (Ayame 1 and 2) after launch. The first satellite impacted the upper stage of its launch vehicle after separation, and the second was lost when the apogee kick motor used to place the satellite in geostationary orbit malfunctioned. In the latter case, the kick motor had been purchased from a U.S. company, and the Japanese subsequently indicated that they would develop their own kick motors for the future.

The Japanese have relied on the N launch vehicle for most of their launches since 1977. In 1981, the Japanese successfully launched the first improved version of the N launch vehicle, N II, which can place 350 kilograms in geostationary orbit. They also announced plans to develop an H-1 vehicle which will be able to place 550 kilograms in geostationary orbit, and will use liquid hydrogen/liquid oxygen fuel. The 1969 agreement with the United States which allows access to the Delta technology prohibits Japan from transferring that technology to third countries and from launching satellites for third countries without prior agreement from the United States. Because of this latter provision, Japan is not seen as a near-term launch competitor

to the United States. Another limiting factor is that, for financial reasons, the Japanese can only launch twice a year because the government is required to compensate the Japanese fishing industry on days when launches occur (for safety reasons, the fisherman cannot be in the water near the launch site).

By the end of 1983, Japan had made 24 successful launches of communications, weather, and scientific satellites.

For the future, Japan continues to have ambitious space plans. Among the approved programs is a mission to Halley's comet, planned for launch in 1985. Called Planet A, the probe would first return data about Venus and then continue on to intercept Halley's comet. As noted earlier, Japan, ESA and the Soviet Union are developing a cooperative agreement for exchange of data from their individual Halley's comet probes. Other approved programs focus on developing more advanced communications, meteorological, and remote sensing satellites. In the latter category, the ERS satellite is scheduled for launch in 1986 and will help explore for oil and mineral resources. Current plans call for the satellite to carry a synthetic aperture radar, a stereo camera, and visible and infrared radiation measurement systems. Also planned is a Marine Observation Satellite for launch in 1985 to study ocean surface temperatures.

In 1981 the Japanese also raised the possibility of launching military reconnaissance satellites. The 1969 space cooperation agreement with the United States requires Japan to use U.S.-derived space technology only for peaceful purposes, so the United States might have to approve any reconnaissance satellite activities the Japanese plan. In 1983, the Japanese Government approved plans for the military to use their CS2 communications satellite, and this apparently did not violate the 1969 agreement.

An even more ambitious proposal is for the construction of a "mini-shuttle." Smaller than the U.S. space shuttle, the Japanese version would have most of the shuttle's basic features, including reusability, and could carry a crew of four. This proposal is in the very early stages of discussion and has not been approved. The Japanese are, however, in the process of selecting one or more persons to fly with Japanese payloads on the space shuttle.